The

Journal of Heredity

(Formerly the American Breeders' Magazine)

Vol. V, No. 12 December, 1914

CONTENTS

Plant Chimeras, by the Editor 520
Essentials of a Free Society, by Francis Galton 531
Photographs of Large Trees Wanted 531
Heredity in Chimeras, by Dr. William S. Chapin 532
Eugenics and Genius, by C. W. Saleeby 544
Studies in Human Heredity, by the Eugenics Research Committee 546
Skin Color in Mulattoes, by Charles B. Davenport 555
The Principles of Eugenics, a Review 557
Missing Teeth Inherited, by Dr. Sergio Sergi 558
The Justification for Eugenics, by Francis Galton 559
Title Page to Volume V 560
Index to Volume V 562

The Journal of Heredity is published monthly by the American Genetic Association (formerly called the American Breeders' Association) for the benefit of its members. Canadian members who desire to receive it should send 25 cents a year, in addition to their regular membership dues of $2, because of additional postage on the magazine; foreign members pay 50 cents extra for the same reason. Price of single copies, 25 cents.

Entered as second-class matter August 27, 1912, at the postoffice at Washington, D. C., under the act of August 24, 1912. Contents copyrighted 1914 by the American Genetic Association. Reproduction of articles or parts of articles permitted provided proper credit is given to author and to the Journal of Heredity (Organ of the American Genetic Association), Washington, D. C.

Date of issue of this number, November 25, 1914.

A "SIAMESE TWIN" PIGWEED

Three plants like this were found growing in a back yard. Investigation shows that they are sectorial chimeras—plants made up of two kinds of tissue (green and white) which remain perfectly distinct, so that one may describe the pigweed as consisting of a white plant and a green plant, each forming part of the whole individual. A streak can be seen running down the main stem of the plant, composed of white tissue like that in the leaves. Many plants with variegated leaves have been studied in recent years, and their surprising manner of heredity explained, partly by mathematical formulas. (Frontispiece.)

PLANT CHIMERAS

Recent Spectacular Productions of Experimental Horticulture—Their Existence Known for Nearly Three Centuries—Only One of Them a True Graft Hybrid.

THE EDITOR

TWO plants of different species grown together so closely that one forms the whole outside like a glove and the other the inside like one's hand; or like Siamese twins, one species forming one side of every part of the plant and the other species the other side: such are plant chimeras, perhaps the most spectacular horticultural discoveries of recent years.

Not that such things were never known before. They were first reported nearly three centuries ago, and doubtless existed centuries earlier, but unnoticed. It was not until lately, however, that their production under experimental conditions, and the study of their cells under the microscope, made it possible for botanists to understand exactly what they were. Now that we know the trick, they can be produced by anyone with patience, and the mystery surrounding the so-called "graft hybrid," a bone of contention among horticulturists for several centuries, has vanished.

Broadly speaking, any plant produced by grafting one species on another is a graft hybrid. Such an operation has been practised since prehistoric times, and at present some plants are almost never grown on their own roots, as the saying is, but are grafted on some hardier stock. Thus the Washington Navel orange in California is regularly grown on some such stock as the pomelo, or the hardy and vigorous *Citrus trifoliata* of Japan; and the resulting trees are, in the broadest sense of the phrase, graft hybrids, being the union of two distinct species through grafting.

But under these conditions, each of the parent species maintains its separate life, as far as the cells are concerned. These only come in contact along the line where the graft was made; the roots remain just what they were—*Citrus trifoliata*, in the case chosen for illustration; the branches remain just what they were—*Citrus aurantium*, the navel orange. Each species exercises a slight influence on the one to which it is united, but in general they maintain their separate identity and their systems of cells come in contact, as was said, only at one plane in the whole plant.

We can go two steps farther in the production of graft hybrids, however. First, we can produce hybrids where the cell systems of the two parents are in contact throughout much or most of the plant; second, it appears that we can produce hybrids where the cells of the two parents actually blend. I shall leave the latter case for discussion further on, and explain in more detail the commoner cases where the two parents bear the relation to each other, in the hybrid, of Siamese twins, or glove to the hand it encases. A short account of the way in which the nature of these chimeras was discovered will perhaps be helpful.

HISTORY OF CHIMERAS.

The first one brought to the attention of men of science was a product of the genus Citrus, and has always been known as the Bizarria—because of its bizarre appearance, of course. It now exists in many forms, and new ones are appearing almost every year. One of the original type is shown in fig. 1 and a recent specimen which sprang into existence in Florida a few years ago is shown in fig. 3. The original Bizarria is said to have appeared in Florence,

THE FIRST RECORDED CHIMERA

The Bizarria, a citrus graft-hybrid which appeared in Florence, Italy, about 1644. Its origin was in a graft between a citron and an orange, and the exact nature of the freak was a matter of hot debate between botanists, which ended only a few years ago in the discoveries of Dr. Erwin Baur and the experiments of Dr. Hans Winkler. The fruit here shown about natural size is part orange and part citron. Photograph from the New York Botanical Garden. (Fig. 1.)

Italy, in the year 1644, where a gardener asserted that he had created it by uniting buds of several different trees. There seems reason to believe that as a fact "the first branch came from a callus at the base of the dead scion of a graft between the orange and the citron." The tree was propagated asexually, by budding or grafting, until it was spread all over Europe; it bore fruits which showed at various times the characters of almost any species of Citrus: orange, lemon, citron, lime. The leaves showed a similar variability. So did the flowers. The old botanists were astounded and confounded. The Bizarria became one of the stock topics of controversy, some claiming it for a graft hybrid, while others thought it could be nothing more than an ordinary sex-hybrid; that is, a hybrid produced by the common method of cross-pollination. But when fruits were brought in which were compounded, to all appearance, of four or five different species, or which were typical lemons on the outside and typical oranges inside, the acutest of the horticulturists had to content themselves with guesswork.

In 1825 another striking graft-hybrid was brought to public notice in the garden of M. Adam near Paris, where two closely related leguminous plants had been grafted together. The stock was the common laburnum of gardens (*Laburnum vulgare*, J. Presl.), on which was grafted a branch of *Cytisus purpureus* Scop., a kind of Scotch Broom. From this graft a branch arose that was somewhat intermediate between the two parents in character, and was propagated under the name of *Cytisus adami* Poit. Its behavior was so freakish that it not only brought poor Adam notoriety, but came near costing him his reputation, some of the greatest

botanists of the time feeling certain that his straightforward account of its origin must be a fairy tale. This particular graft hybrid showed itself, when propagated, to be inconstant in character, tending to revert to one of the parent forms, so it is not unusual to find a tree of *Cytisus adami* on some branches of which are borne the yellow blossoms of the laburnum, on others the purple blossoms of the broom, and on still others a mixed form showing the influence of both. In this case several eminent botanists insisted that the branch used by Adam in his original graft must have been taken from a sex-hybrid plant, a view that has not wholly been given up yet,[1] although hardly tenable in the light of our present knowledge of chimeras.

THE WHITETHORN MEDLAR.

The third classical example is that of the medlar (*Mespilus germanica*) near Metz, Germany, on which a branch of whitethorn (*Crataegus monogyna*) was grafted more than a century ago. From the graft there grew three sprouts which showed various blends of the characters of the two parents. The original tree, references to which abound in botanical literature, is still in existence; its hybrid shoots when propagated show a constant tendency to revert to one of the parent types.

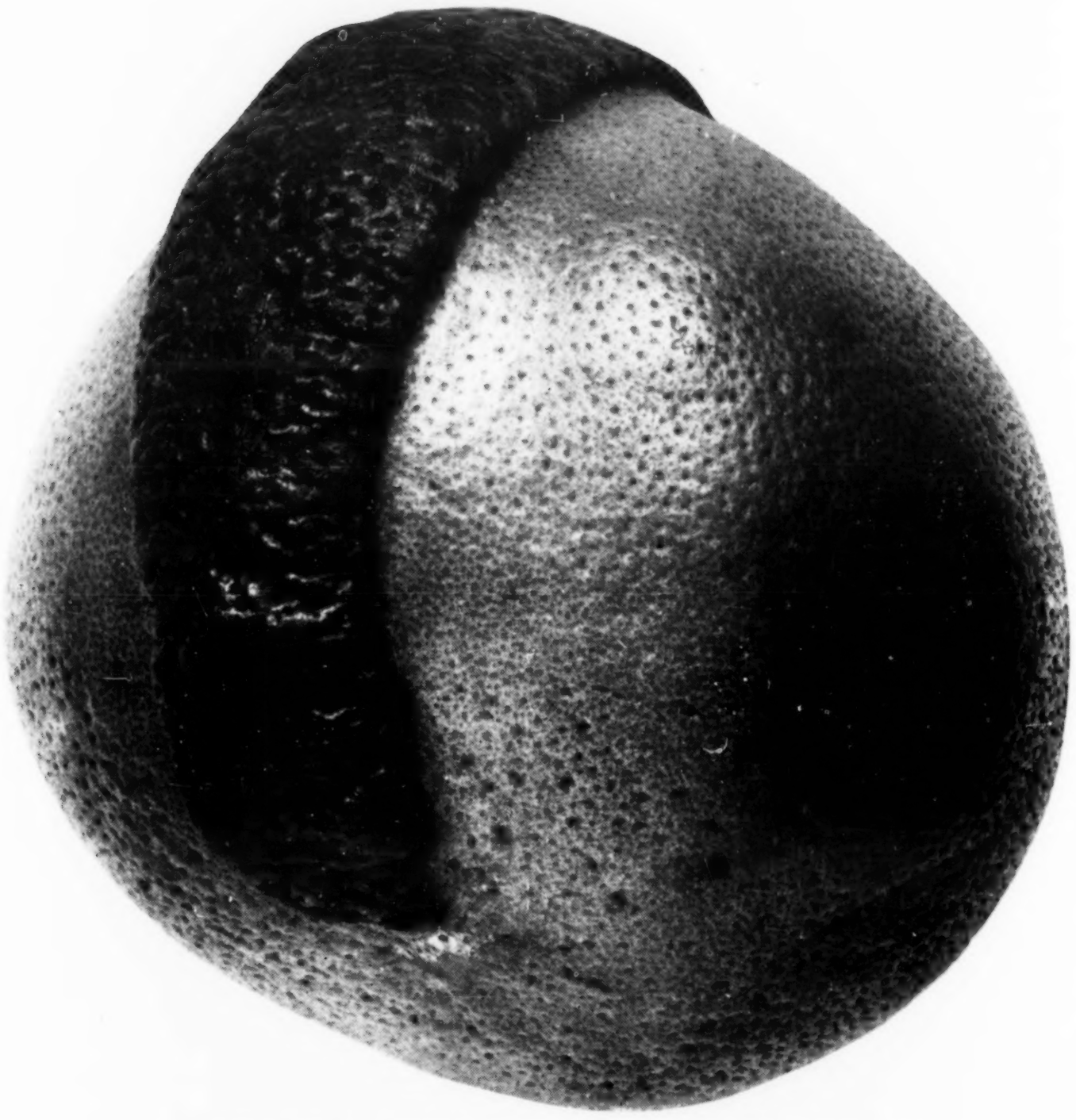
These examples indicate how chimeras, or graft-hybrids of a pronounced type, originate unexpectedly. With the growth of the experimental method in botany came a realization that the only way to settle the problem of the origin of these freaks was to produce similar ones in the laboratory under controlled conditions. Dr. Hans Winkler, then at the University of Tubingen but now director of the State Institute of Botany at Hamburg, Germany, undertook the task with spectacular success.

For his material he selected the tomato (*Solanum lycopersicum* or, according to the latest American nomenclature, *Lycopersicon esculentum*) and the nightshade (*Solanum nigrum*). These species are closely enough related to be handled conveniently, and yet differ markedly enough in general appearance to be identified easily by comparison. He grafted them on each other, reciprocally, using the common cleft or saddle graft, and after the graft had "taken" he cut through the stem of the plant at the point of graft, in such a way that the surface exposed contained sections of both parents (see fig. 4, A. B. and C.). The wound healed over with the formation of a callus, and, as usual, sprouts or "adventive shoots" grew up from it. Some of these sprouts grew from the part of the surface containing tomato plant tissue, some from that part containing nightshade tissue,

CALLUS TISSUE

Cutting showing the formation of callus around the edges, gradually spreading inward until it covers the whole wound. At this stage the callus tissue is soft and translucent; later it hardens and from it arise roots, if the cutting is planted (as in this case) or shoots, if the cut is above ground. From such sprouts plant chimeras are obtained. Photograph enlarged eight diameters. (Fig. 2.)

[1] At the Fourth International Conference on Genetics in Paris, 1911, L. Blaringhem upheld the idea that it was a sex-hybrid showing mosaic inheritance.



PROBABLE CHIMERA OF RECENT ORIGIN

Grapefruit from Florida which has apparently thrown out a section of orange. Such freaks are fairly common in all kinds of citrous fruits, and are sometimes explained as sectorial bud sports or variations. Apparently this fruit is made partly of grapefruit tissue and partly of orange tissue. How did the orange tissue get there? If it was in the bud to start with, having survived from the graft, then this is a real sectorial chimera. But if part of the grapefruit tissue suddenly changed into orange tissue, then this is not a chimera, in the usual sense of the word, but merely a bud sport or variation. It has frequently been explained as such, although there is not sufficient evidence that grapefruit tissue really can turn into orange tissue, in that way. Granted that it does, the fruit might be considered a spontaneous chimera. (Fig. 3.)

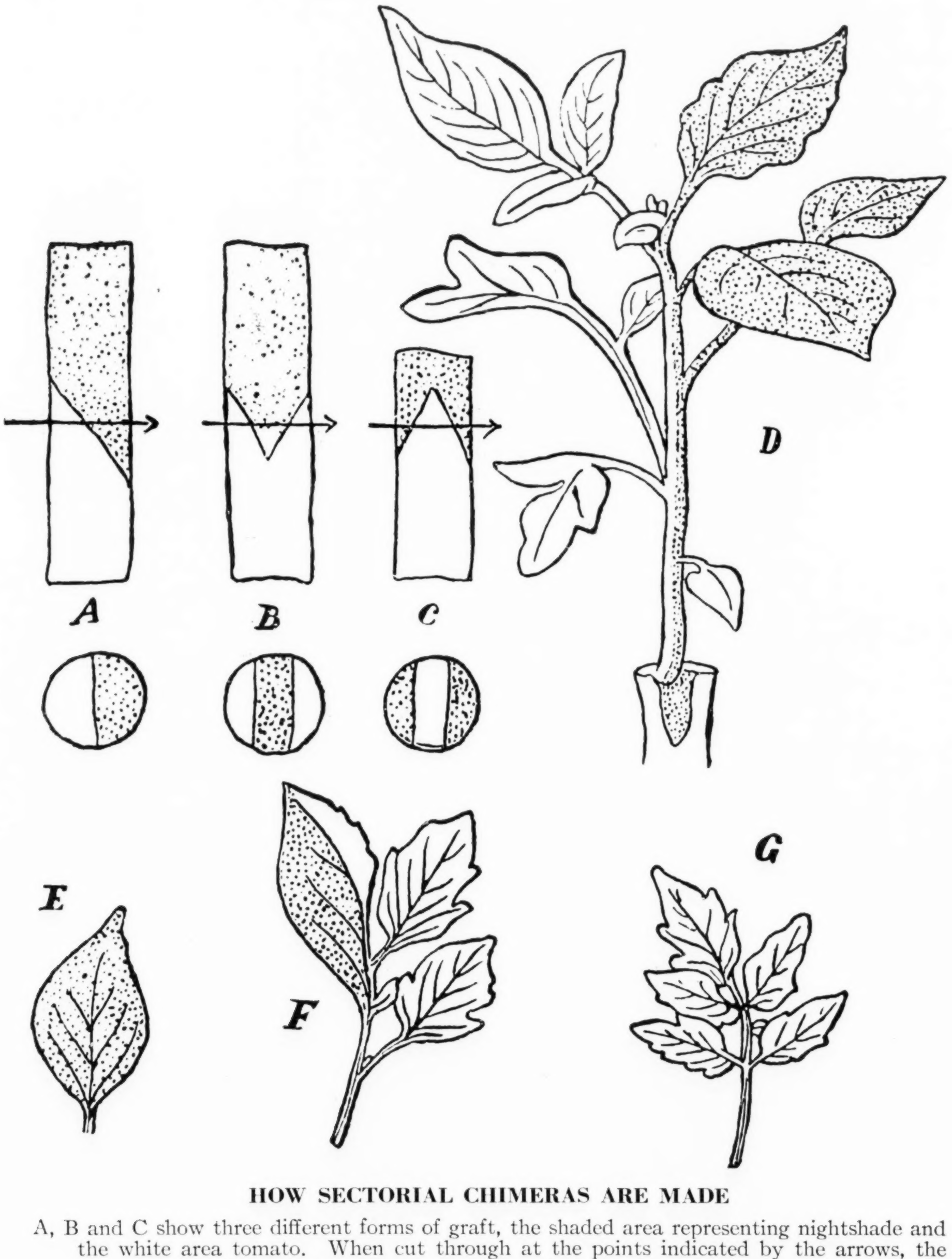
and some grew on the lines where these two kinds of tissue came together.

PRODUCTION OF BLEND.

The sprouts from tomato tissue produced tomato plants. The sprouts from nightshade tissue produced nightshade plants. But the sprouts which grew from points of union of the two kinds of tissue were neither the one nor the other; they were both! For the first time, graft-hybrids of this type had been experimentally produced.

In these first chimeras, the glove-and-hand relationship did not exist. The relationship was like that of the Siamese twins, the two plants existing side by side in the same stem and leaves, and yet retaining their identity. One side of the stem, with the leaves and flowers appertaining to it, was characteristically tomato, the other side was just as indisputably nightshade (see fig. 4, D.E.F. and G.). In a cross section of the main stem, each kind of tissue occupies a distinct segment or sector; these graft-hybrids, therefore, are known as *sectorial chimeras*.

This success did not satisfy Dr. Winkler, and he continued with his



HOW SECTORIAL CHIMERAS ARE MADE

A, B and C show three different forms of graft, the shaded area representing nightshade and the white area tomato. When cut through at the points indicated by the arrows, the stems present the appearance in cross-section of the circles underneath them. The cut surface forms a callus, a sort of scab, from which sprouts put forth; if one of them arises directly over the line of union of the two kinds of tissue, it will draw half of its substance from each, as shown in D, where the left-hand side of the plant is tomato and the right hand nightshade. For the purpose of comparison, a nightshade leaf is shown at E and a tomato leaf at G; a chimera-leaf made up of both plants is represented in F. After Winkler. (Fig. 4.)

experiments. In 1908 he at last succeeded in producing what he wanted—a graft-hybrid in which the union was not a mere partnership between species retaining each its own individuality, but in which the two actually blended into something new. After the number of attempts had run up into the hundreds, he finally observed a sprout "which when propagated produced plants having leaves, flowers and fruit which were different from those either of the tomato or of the nightshade. This new form was named *Solanum tubingense*. The general appearance of this type is intermediate between the tomato and the nightshade. The leaves are simple, sharply serrate and often lobed much like the leaflets of the tomato plant. The stems and leaves are hairy like the tomato. The corolla and the calyx are larger than those of the nightshade but smaller than those of the tomato. The fruit is slightly larger than the fruits of the nightshade, which are much smaller than the fruits of the variety of the tomato used in the graft. Many of the fruits of this type are sterile but several generations of seedlings grown from seed have been pure nightshade and are not like the plants *Solanum tubingense* from which they were derived.

"In continuing his experiments Dr. Winkler soon obtained the three other types of tomato-nightshade chimeras shown in the plate illustrating this article. *Solanum gaertnerianum* resembles the nightshade more than the tomato. The leaves are less entire than those of the nightshade. The flowers are greenish in color and are dwarfed, the petals remaining rudimentary. This form fruits sparsely but some seeds are perfectly developed and produce pure nightshade plants.

"In general shape the leaves of the form *Solanum koelreuterianum* resemble strongly the tomato, but the epidermis is free of hairs like the nightshade. The flowers are white with yellow middle streaks. The fruit does not mature. This particular type has appeared several different times.

"The form called *Solanum proteus* also resembles the tomato more than the nightshade, although not to the extent of leaf shape seen in *S. koelreuterianum*. The stems and leaves are hairy. The fruits produced are smaller than those of the tomato, but resemble them in form."[2]

THE CHIMERAS EXPLAINED.

Winkler's success now seemed complete: he had produced four plants that in appearance were genuine graft-hybrids in which the two parents were wholly blended. The exact nature of his success had not yet been explained, however, and this explanation remained for another German, Dr. Erwin Baur of Berlin, who had been studying with a microscope the cells in the leaves of that very common perennial, the variegated geranium (*Pelargonium zonale*). Everyone knew that some geraniums bear partly green leaves and partly white ones, and that there are well-fixed commercial varieties which regularly bear green leaves with white edges. Baur wanted to know why this happened, so he began to raise sectorial chimeras, made up of green geranium and white geranium. It will be remembered that, in favorable cases, these two kinds of tissue exist side by side all the way up the stem and in the terminal bud.

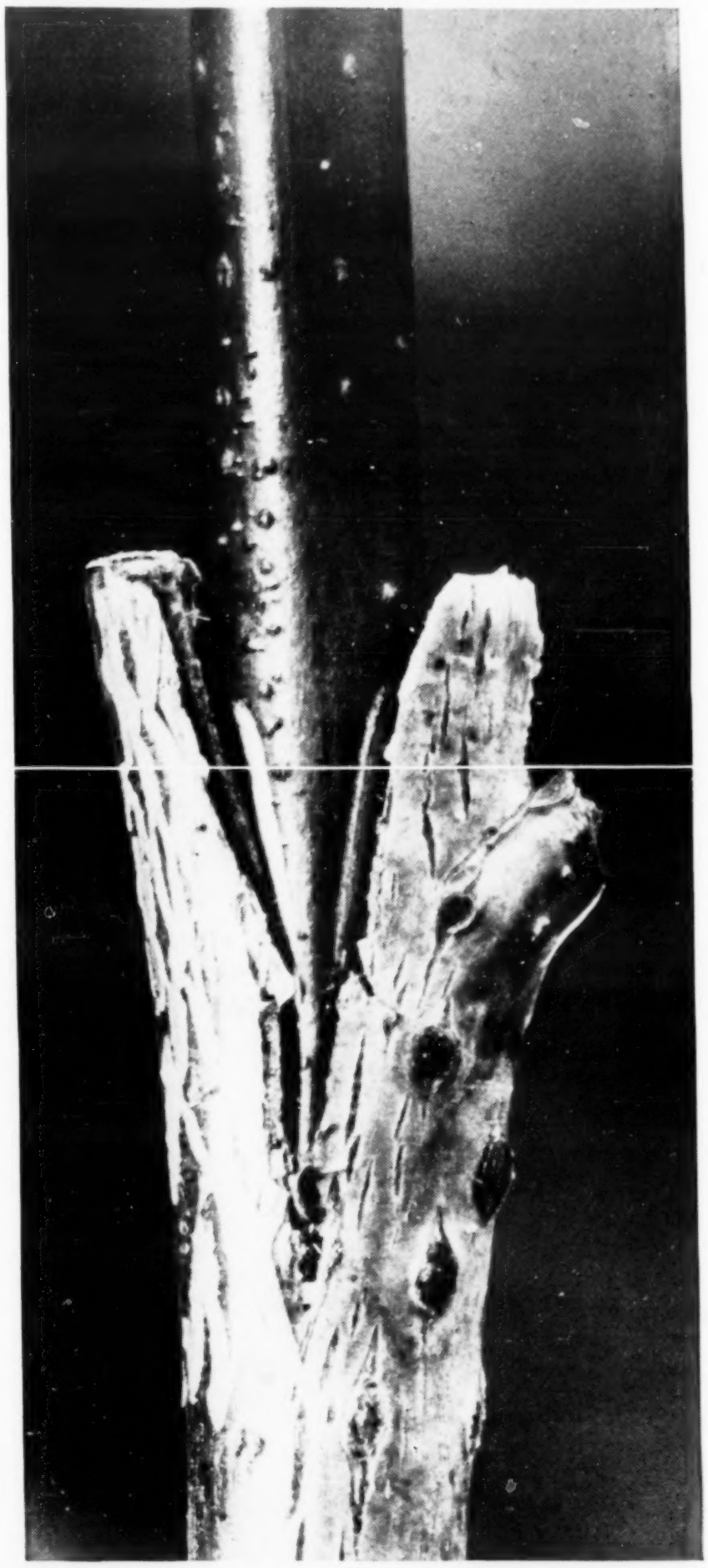
Now suppose that in this terminal bud, where the two kinds of cells are side by side, the white cells at the surface begin to grow a bit faster than the neighboring green cells, so that they crowd over a little way into the green territory. Then we have part of the

[2] Stout, A. B. Plant Chimeras. Journal of N. Y. Botanical Garden, XIV, 164, pp. 145-150, August, 1913. Winkler last year sent rooted specimens of these four chimeras to the New York garden, where they have been propagated and distributed to several institutions in the United States. In a letter dated Oct. 7, Dr. Stout says: "During the past summer, the chimeras have done poorly, and do not seem to reproduce readily through cuttings, although we have made extra efforts to secure most favorable conditions for them. One of the chimeras, gaertnerianum, has died out completely. I find that tubingense and koelreuterianum are the only ones that are inclined to make big, bushy plants. I saw Winkler's chimeras at Hamburg during the past summer. None of them were big, lusty plants. He propagates from terminal and sides branches, getting young and rather small plants. I have secured the pure tomato and pure nightshade seeds of chimeras and they grow very well."

green tissue in the terminal bud overlaid by a layer or two of white cells. Now if a branch starts out just at this point where the green cells have been overlaid by white, it will start from and with green tissue, but it will have to make its way through this skin of white cells, and will take them along with it as its own outer tissue. As the branch grows, the white cells grow along with it on its surface, still retaining their connection with their parent white tissue, while the larger part of the branch —namely, all the interior part—is made of the green tissue. So when the branch finally attains its full size it might be described, figuratively, as consisting of a white branch and leaves, hollow, into which a green branch and leaves of the same shape but a little smaller have been thrust up. In other words, it is a hand in a glove. Most of each leaf appears green, because the thin layer of white cells is underlaid by so much green tissue that shows through; but at the edges of the leaves the green cells were crowded back, the white cells hold undisputed possession, and no green is to be seen, the result being the white edge around the periphery of the leaf. Because of this peripheral distribution of the white cells, Baur called such chimeras *periclinal*, to distinguish them from the sectorial chimeras which both he and Winkler had produced in the earlier stages of their experiments.

THE SOLANUM CHIMERAS.

It was at once suggested that Winkler's later chimeras—those of the blended or intermediate type, which he himself had never been able satisfactorily to explain—were periclinal chimeras. He made a careful examination of them on this hypothesis, and reported that such was the fact. In *Solanum tubingense* and *S. proteus*, he found that the entire body of the plant, consisting of nightshade, was overlaid by a film of tomato tissue, in the former case consisting of only one layer of tomato cells, and in the latter case of two. *Solanum gaertnerianum* and *S. koelreuterianum* were found to be tomato at heart, but wholly clad in a skin of nightshade, the

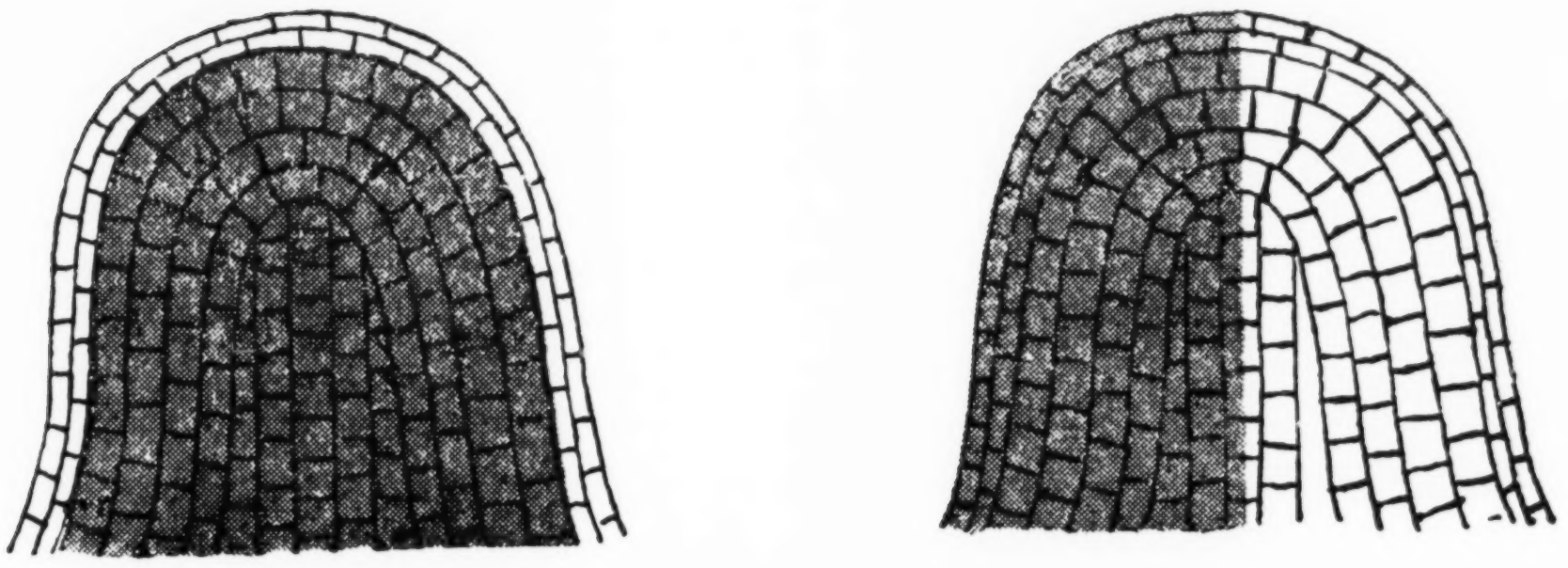


SIMPLE GRAFT

This illustrates the simplest form of graft—a split, cleft or wedge graft. Of the two plants thus united, the lower one, which furnishes the root system, is called the stock; the upper one, which furnishes the branches of the developed plant, is known as the scion. When the scion is inserted in the stock, as here shown, and the graft bound up, callus tissue forms at all the points of juncture. To produce chimeras the whole graft, after it has "taken," is cut in two along the line shown, so that the cut surface on top includes parts of both stock and scion; more callus forms on this top plane and gives rise to sprouts which, in favorable cases, show the characters of both parents. Enlarged eight diameters. (Fig. 5.)

WINKLER'S SOLANUM CHIMERAS

These plants were produced by grafting tomato on nightshade (and vice versa) and then decapitating the graft, cutting through the points of contact between scion and stock. From left to right, the plants are *Solanum gaertnerianum, S. koelreuterianum, S. proteus* and *S. tubingense*. As will be seen, the first one resembles the nightshade more than the tomato parent, the second inclines more to the tomato, the third is somewhat similar, while the fourth again resembles the nightshade. The last two have a nightshade body covered with tomato cells, the first two have a tomato body covered with nightshade cells. Such freaks are called periclinal chimeras. Photograph from the New York Botanical Garden. (Fig. 6.)



TWO FORMS OF CHIMERAS

Diagram after Baur showing the difference between sectorial and periclinal chimeras, as exhibited in the terminal bud. The bud at the left (No. 1) may be taken to represent a periclinal chimera between a white plant and a green plant; the green tissue is entirely overlaid with a layer of white cells, so that any branch sent out from the green tissue must of necessity pass through and carry with it white cells as an outer skin. At the right (No. 2) is the bud of a sectorial chimera between white and green plants, where the two kinds of tissue exist side by side and come in contact only in one plane. Obviously, any branch sent out from the green tissue will be green, any branch sent out from the white side will be white. It is only a branch arising exactly on the line of juncture of the two kinds of tissue that may be expected to carry both kinds of cells and thus form a sectorial chimera. (Fig. 7.)

latter sort of cells being two layers deep in *S. gaertnerianum*, while *S. koelreuterianum* had but one layer.

As soon as it was understood what this kind of graft-hybridization really meant, attention at once reverted, of course, to the classic specimens. *Cytisus adami* was found to be a laburnum in disguise, so to speak—a laburnum with the skin of a purple broom. Baur demonstrated that the Crataego-mespilus was also a periclinal chimera, its epidermis being derived from the medlar and its interior from the whitethorn. By common consent, the Bizarria was separated from these and put in the class of sectorial chimeras.

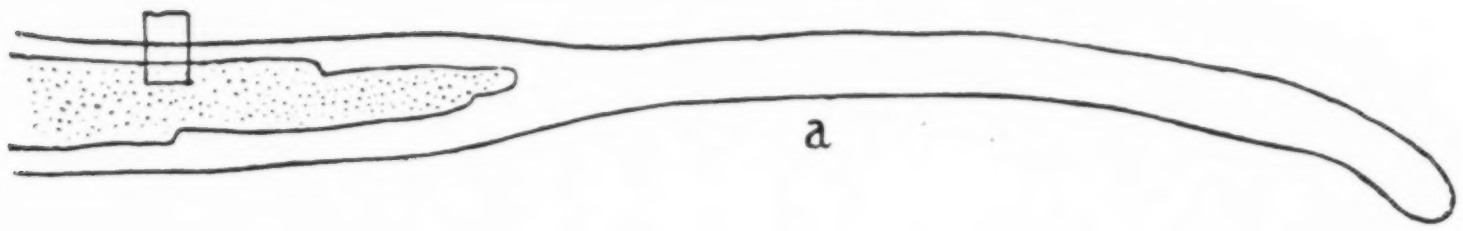
Since then many other chimeras, belonging to one or other of these two classes, have been produced, or have been found in nature, particularly in such variegated plants as Coleus.[3] One of the most recent was produced by grafting a peach on an almond. The first crop borne consisted of true peaches, but in the next year the tree produced buds some of which resembled those of an almond, while others were like peach buds and others again were intermediate. Seeds from the graft produced trees which in foliage resembled both the parents. An apparent chimera made of two varieties of rhododendron was produced by grafting Madame Linden on Cunningham's White. "A shoot which had been left on the stock just below the graft produced pale rosy-lilac flowers; whereas the flowers of the stock are white, and those of the scion deep rosy-lilac with dark red spots. The form of leaf borne by the anomalous shoot is also distinct, approaching that of the scion."[4] If more horticulturists would make the attempt, it is probable that the number of chimeras reported would be very large. Winkler has pointed out[5] num-

[3] See also Castle, W. E. An Apple Chimera. JOURNAL OF HEREDITY, V, 5, pp. 200-202, Washington, May, 1914.

[4] Revue Horticole, Paris, August 1, 1913, and September 1, 1913; abstract in Gardeners Chronicle, London, May 16, 1914.

[5] Die Chimärenforschung als Methode der experimentellen Biologie, in Sitzungsberichten der phys.-med. Ges. zu Würzburg, 1913. For the original reports of his work, see Winkler, Hans. Ueber Pfropfbastarde u. pflanzliche Chimären, Ber. d. deutsch. Botan. Ges., 25, 568, 1907; same author, *Solanum Tubingense*, ein echter Pfropfbastard zwischen Tomate u. Nachtschatten, ibid., 26, 595, 1908; and the same journal, *passim*, during those and the following years, for the views of the leading German botanists on the whole subject. The files of the Gardeners' Chronicle (London) may also be consulted with profit by those interested in graft-hybrids.

Photograph from the New York Botanical Garden. (Fig. 6.)



LIKE A FINGER IN A GLOVE

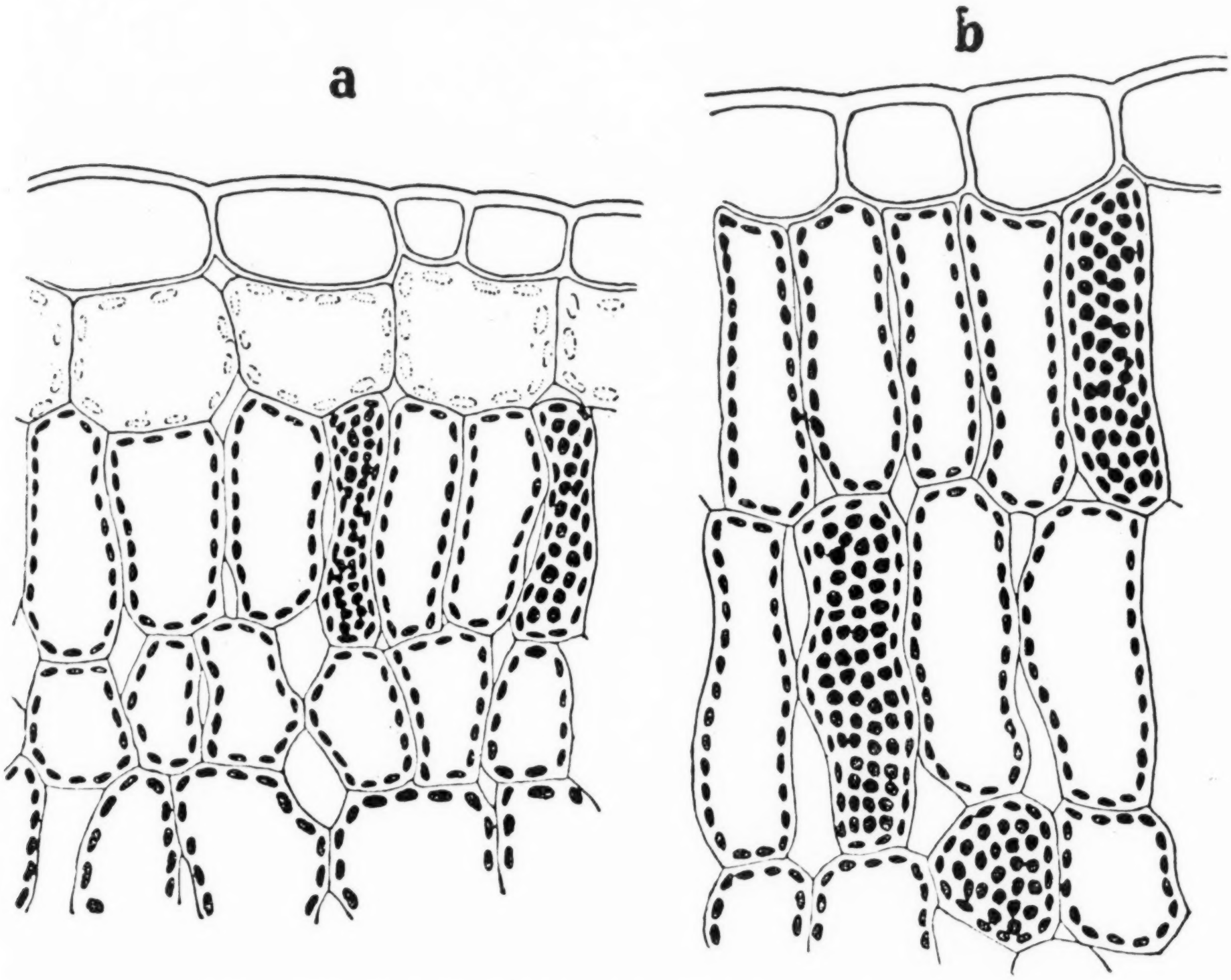
Diagram of edges of two geranium leaves in cross-section, after Baur. (a) is that of a variegated geranium; the outer part is white, but inside there is a mass of green tissue, entirely overlaid by white. (b) is a normal green leaved geranium, no white cells being present. The section enclosed in the small rectangle in each one is shown enlarged in Fig. 9, the following illustration. (Fig. 8.)

erous ways in which experiments with them may yield commercial results, as well as throw light on problems of plant physiology and heredity, and the study of chimeras is probably destined to become a regular part of experimental horticulture. It is not always easy, however: Winkler made 268 grafts, which resulted in the production of more than 3000 sprouts, in order to get the five chimeras which stand to his credit.

THE TEST OF BREEDING.

Discovery of the nature of these chimeras was made possible only by the association of the microscope with genetics, for mere observation of their behavior when propagated would hardly have cleared up the mystery. If they are to be considered really hybrids, they ought theoretically to represent the hybrid generation (F_1) in spite of the fact that they were produced by grafts rather than seeds. Their own seedlings should then represent the critical second filial (F_2) generation, and either show a new type that bred true (a behavior that, in hybrids of distinct species, would occasion no great surprise) or else split up into a variety of forms, as most hybrids do in that generation. It has already been mentioned that the seedlings of *Solanum tubingense* were nothing more nor less than little nightshades, which bred true in all succeeding generations. Similar results were found with the other three chimeras, each one breeding true to the parent which it most resembled.

Another suggested test was to compare them with the normal sex-hybrids produced by cross-pollinating the tomato and nightshade. This could not be done, however, because the investigators were not able successfully to cross those two species. There was one line of attack left—namely, a study of the cell contents. Those who possess an elementary knowledge of biology know that each cell has a nucleus containing certain little rods of easily-stained material called chromosomes, that the number of chromosomes varies from species to species, but that within each species it is constant. This, therefore, gave a means of identifying either one of the parents found in the sectorial chimeras. The tomato possesses 24 chromosomes, the nightshade 72. In a real hybrid, the number of chromosomes would, by expectation, be the sum of half of each of these numbers, that is, $12+36=48$. On the other hand, as this hybrid was created by vegetative means, the reduction to one-half the normal number, which occurs in the chromosomes in sexual conjugation, might conceivably not take place; if it did not, the sectorial chimeras would be expected to possess $24+72=96$ chromosomes. So the microscope was brought out, and the chromosomes of



HOW THE GREEN CELLS ARE OVERLAID BY WHITE

Highly magnified cross section of parts of geranium leaves, after Baur. At the top of each one is seen a colorless layer of cells forming the epidermis, and common to all geraniums. (a) represents a variegated geranium; below the epidermis is seen a single layer of almost colorless cells which come from a white plant. They are found not only at the surface of this leaf, but of all the other leaves and stems of the plant. Below this layer of white cells is the mass of green cells, bearing chlorophyll granules, which make up the body of this variegated plant. (b) shows part of the leaf of an ordinary green geranium. There are no white cells, the whole plant being made up of green tissue. The essence of a chimera is that it be composed of tissues from two different plants. (Fig. 9.)

pollen grains and ovules from all the new Solanums eagerly counted, with the expectation or at least the hope that the number found would be either 48 or 96. But the only counts secured were either 24 or 72; each chimera possessed the chromosome count of the parent which it most resembled, just as it reproduced that parent by seed.

ARE THE CHIMERAS HYBRIDS?

In the face of such results, the Solanums which Winkler had created with so much difficulty could hardly have ranked as hybrids of any kind, had not Baur's work showed the ingenious and unexpected way in which the two parents actually entered into the progeny, by the hand-in-glove method. As far as the evidence from breeding and from chromosome counts went, they would have had to be thrown out of the hybrid class; and this perhaps is the proper course after all, in spite of the fact that they are undeniable graft-hybrids, in the broadest sense of the term. If they are merely designated as chimeras, the term hybrid can be reserved for plants which more completely share the germplasm of their parents, and confusion will thereby be obviated.

But there is one more chimera, which was alluded to near the beginning of this paper and has since, for the sake of

simplicity, been studiously ignored. This, the fifth chimera secured by Winkler, and called by him, *Solanum darwinianum*, is in a different class from its predecessors. It appears to be a real graft-hybrid: indeed, it claims to be the only genuine, out-and-out graft-hybrid in the world.

In order to make this claim, it will be understood from what was just said that the chimera must show evidence of actual vegetative cell-fusion. It will not do to have the parents living side by side, as in a sectorial chimera, or even one enveloping the other, as in the periclinal chimera. They must actually unite, not only in body but particularly in germ-plasm. In *Solanum darwinianum* the tomato and nightshade seem at last to have reached that stage of union.

A count of the chromosomes shows their number to be 48. The evidence, therefore, indicates on its face that the cells (or at least some of the cells) of the two parents have here actually combined, each previously throwing out half of its chromosomes, as in normal sexual cell-conjugation. Just how this may have taken place is not yet entirely explicable, but if it has happened, *Solanum darwinianum* will have a strong claim to be considered a real graft-hybrid, the first one ever known.

To the old botanists, the existence of supposed graft-hybrids seems at times to have been rather resented—they interfered so much with theories about heredity! Fortunately we have passed that stage. "It is not too soon to say," as Goldschmidt[6] concludes, "that the idea that production of hybrids by vegetative propagation would upset all our fundamental ideas of the laws of heredity is to be considered absolutely groundless." There are still some problems to be solved, but we are not afraid that chimeras will complicate them. "On the contrary, the periclinal chimeras, and still more the sectorial chimeras, have introduced some extraordinarily important ideas in the solution of all kinds of genetic, morphological and physiological problems."

[6] Goldschmidt, Richard. Einführung in die Vererbungswissenschaft, p. 400. Leipzig und Berlin, 1913.

Essentials of a Free Society

Our present natural dispositions make it impossible for us to attain the ideal standard of a nation of men all judging soberly for themselves, and therefore the slavishness of the mass of our countrymen, in morals and intellect, must be an admitted fact in all schemes of regenerative policy.

The hereditary taint due to the primeval barbarism of our race, and maintained by later influences, will have to be bred out of it before our descendants can rise to the position of free members of an intelligent society; and I may add that the most likely nest at the present time, for self-reliant natures, is to be found in states founded and maintained by emigrants.—Francis Galton: Inquiries into Human Faculty (1907).

Photographs of Large Trees Wanted

In order to secure data of value to forestry, two members of the American Genetic Association have offered $100 each, for prizes to be awarded by this association for photographs of the largest native trees. Contestants are required to send in two photographs of each tree, one showing the entire tree and the other only the trunk. A prize of $100 will be given for the largest nut-bearing tree and another prize of the same size for the largest forest or shade tree, non-nut-bearing. The competition is not limited to members of this association, but photographs must be taken by or under the direction of the competitor. Conifers will not be considered. As much information as possible must be furnished about the tree which is photographed. Details regarding the contest were published in the JOURNAL OF HEREDITY for October, 1914 (Vol. V, No. 10), or may be secured by addressing the editor of the JOURNAL.

HEREDITY IN CHIMERAS

Pigweed with Variegated Leaves Proves to Be Sectorial Chimera—Variegated Plants Probably Produced by Mating of Green and White Gametes—Review of Present State of Knowledge of Chlorophyll Inheritance.

DR. WILLIAM S. CHAPIN, *Vanderbilt, Mich.*

IN AUGUST, 1912, I found three variegated-leaved pigweeds, *Amaranthus retroflexus*, growing within a yard of each other in a neglected corner of an old garden. I removed the healthiest plant to a large flower-pot in the house, where it started to blossom a week later. Beyond keeping it in the window, I made no effort to protect it from wind-borne pollen from outdoors.

The peculiar thing about these three pigweeds was their leaves, many of which had irregular patches of white where the chloroplasts had failed to develop. A few leaves were pure white while those on the other side of the stem were pure green. The white tissue, not being able to elaborate carbohydrates for itself, had to depend for food on that brought to it from the green portions of the plant. Consequently the white patches showed less growth than the rest of the leaf and this often caused the leaves to bend or curl toward the white areas. Such variegated plants are handicapped in the "Struggle for Existence" when in competition with green plants which have no parasitic white tissue to support and, if they have a large proportion of white tissue, are delicate and hard to raise.

The side branches also bore the character of the leaves from whose axils they sprung: e. g., pure green branches came from the axils of pure green leaves, pure white branches from the axils of pure white leaves, while from the axils of variegated leaves there might appear pure white, pure green or variegated branches depending on circumstances. It is believed that in such plants the apical cone, or mass of embryonic cells at the tip of the stem, is composed of two kinds of cells, some of which are able to produce green tissue while the others can only produce white. If all the white tissue embryonic cells happen to be bunched together on one side of the apical cone, the leaves formed from these cells alone will be pure white, while leaves on the other side of the stem formed only from green tissue embryonic cells will be pure green. Leaves formed from both sorts of cells are variegated and their pattern depends on the relative number and position of the green and white cells.

VARIATION IN THE LEAVES.

If the white and green embryonic cells always maintained their relative numbers and position in the apical cone, then theoretically each leaf on a stem might have the same pattern as the leaf directly below it. There is in fact a very strong resemblance between such leaves, but there is always some inequality in the growth of the cells of the apical cone with a consequent change in the pattern of the leaves. In some cases the green embryonic cells crowd the white ones entirely out of the apical cone or vice versa and the rest of the stem and leaves becomes pure green or pure white as the case may be. Such branches have never again become variegated so far as I have observed. In many variegated-leaved plants the white embryonic cells form a layer over the green ones in the apical cone. The leaves in such cases are a lighter green with white edges, the green cells being sandwiched in, so to speak, between an upper

and a lower layer of white cells. An illustration of this is to be seen in the variegated-leaved geraniums which are familiar to everyone. This type of variegation has never as yet appeared in the offspring of my pigweed.

About half of the seeds of the transplanted pigweed were planted in sterile soil in the spring of 1913. A few seeds from all green branches were saved separately. The results are given in Table 1.

TABLE 1. VARIEGATED PIGWEED 1.

Seedlings	Mixed seed		Seed from green branches	
	No.	%	No.	%
Green plants	419	74	201	98
Variegated plants	11	2	0	0
White plants	134	24	4	2
Total	564	100	205	100

The contrast between the seedlings from the whole plant and those from the green branches alone seemed to be too great to be due to chance so the experiment was repeated by saving the three most vigorous variegated seedlings which were called 1A, 1B, 1C. Each plant was placed in a separate box of earth and protected from outside pollen as far as possible by a cage with a glass top and two layers of heavy muslin on the sides.

An all green slip from 1A was rooted in the house and its seed saved separately. As it was impossible to raise a pure white seedling or an all white slip, I saved some seeds by hand from a pure white branch on 1A. In the other two pigweeds the white and green tissues were so mixed that it was difficult to save seeds from the white tissue alone without including some from the green portions of the plant. The white tissue was also in much smaller amount in these plants than on plant 1A which probably accounts for the smaller proportion of white seedlings which they produced. A few seeds from the green branches of 1A were also saved by hand and most of them planted soon after they were gathered. To my great surprise not a seed came up and after standing around for several months, the box met with an accident and the seeds were lost. This showed that the seeds would have to mature before they would germinate so I waited until this spring before planting the rest of the seeds. The results are given in tables 2 and 3.

TABLE 2. VARIEGATED PIGWEED 1A.

Seedlings	Mixed seed from whole plant		Seed from 1A green slip		Seed from green branches 38 seeds		Seeds from white branches 165 seeds	
	No.	%	No.	%	No.	%	No.	%
Green	2605	62.3	1243	100	32	97.0	4	2.4
Variegated	38	0.9	0	0	0	0.0	0	0.0
White	1541	36.8	0	0	1	3.0	161	97.6
Total	4184	100.	1243	100.	33	100.	165	100.

Note. The four green seedlings in the right-hand column from seed taken from white branches come probably from wild seeds which were not killed in sterilization of the earth. The earth in this case was boiled for half an hour with occasional stirring in an open pan. In all other cases the earth was baked in a hot oven for at least three hours and then washed with three or four changes of water to remove any injurious substances which might be formed by the heat. That the earth in this box was insufficiently sterilized is shown by the fact that two other weeds, *Malva rotundifolia*, also appeared in this box. All the other boxes remained free from foreign weeds.

TABLE 3. VARIEGATED PIGWEEDS 1B AND 1C.

Seedlings	1B Mixed seed No.	1B Mixed seed %	1C Mixed seed No.	1C Mixed seed %
Green	2996	91.5	2413	91.6
Variegated	7	0.2	10	0.4
White	272	8.3	211	8.0
Total	3275	100.	2634	100.

Fifty-seven green seedlings of the original pigweed 1 were raised until they had five or more leaves. None of them showed the least variegation with white tissue, however. Twenty of these plants were placed together in a box where there was abundant opportunity for cross as well as self pollination. No attempt was made to avoid foreign pollen as this would come from green plants anyway and would not be likely to prevent the formation of white or variegated plants, if such could occur. As a matter of fact there were no wild pigweeds growing within a hundred feet of them. From the mixed seed of these plants a large sample was planted and I obtained 3492 seedlings, which were all green, none variegated or white.

From this it would appear in the case of these pigweeds that green tissue produces only green plants and white tissue only white plants when fertilization takes place between germ cells which come from the same tissue. Variegated plants are most likely formed from a cross between germ cells which come one from green and the other from white tissue. I have experiments planned for the future to determine this point, which will be the subject of another paper.

A word should be said as to the accuracy of these figures. I believe that they are essentially correct. The white seedlings always wither before the new leaves appear and if a way could be found to raise them some might prove to be variegated. This seems unlikely, however. A more important source of error consists in overlooking variegated plants which have only a little white in their cotyledons and counting them as green. I doubt if this error would amount to half of one per cent at the most.

The important thing is that we have here a race of plants with different hereditary characteristics on different branches. They are in fact natural chimeras, in distinction to those chimeras which are formed by grafting. If we could graft the white plants on green plants we might expect to get just such sorts of variegated individuals from adventitious shoots which included tissue from both stock and scion.

Baur (4) has reported a very similar condition among geraniums, *Pelargonium zonale*, which have white-edged leaves. The whole subject is so interesting from a genetic standpoint that I shall attempt a review of the main features of chlorophyll inheritance, and the hypotheses put forward to explain them. Besides the cases which I have given in this review others have been reported which do not seem to belong to any of these types. H. Molisch (13), for instance, has reported cabbages which develop variegated leaves on the approach of cold weather. The leaves become green again if the temperature is raised. The plants are true to seed, but no crosses with green plants were reported. Shull (16) also reports some very interesting variegations in the leaves of Melandrium.

CLASSIFICATION OF CHLOROPHYLL INHERITANCE.

1. Infectious Chlorosis. Not inherited. Transmitted only by grafting.

2. Mendelian Types of Inheritance.

(a) Chlorophyll albinos. Forms which lack chlorophyll entirely. Known only as seedlings which soon die.

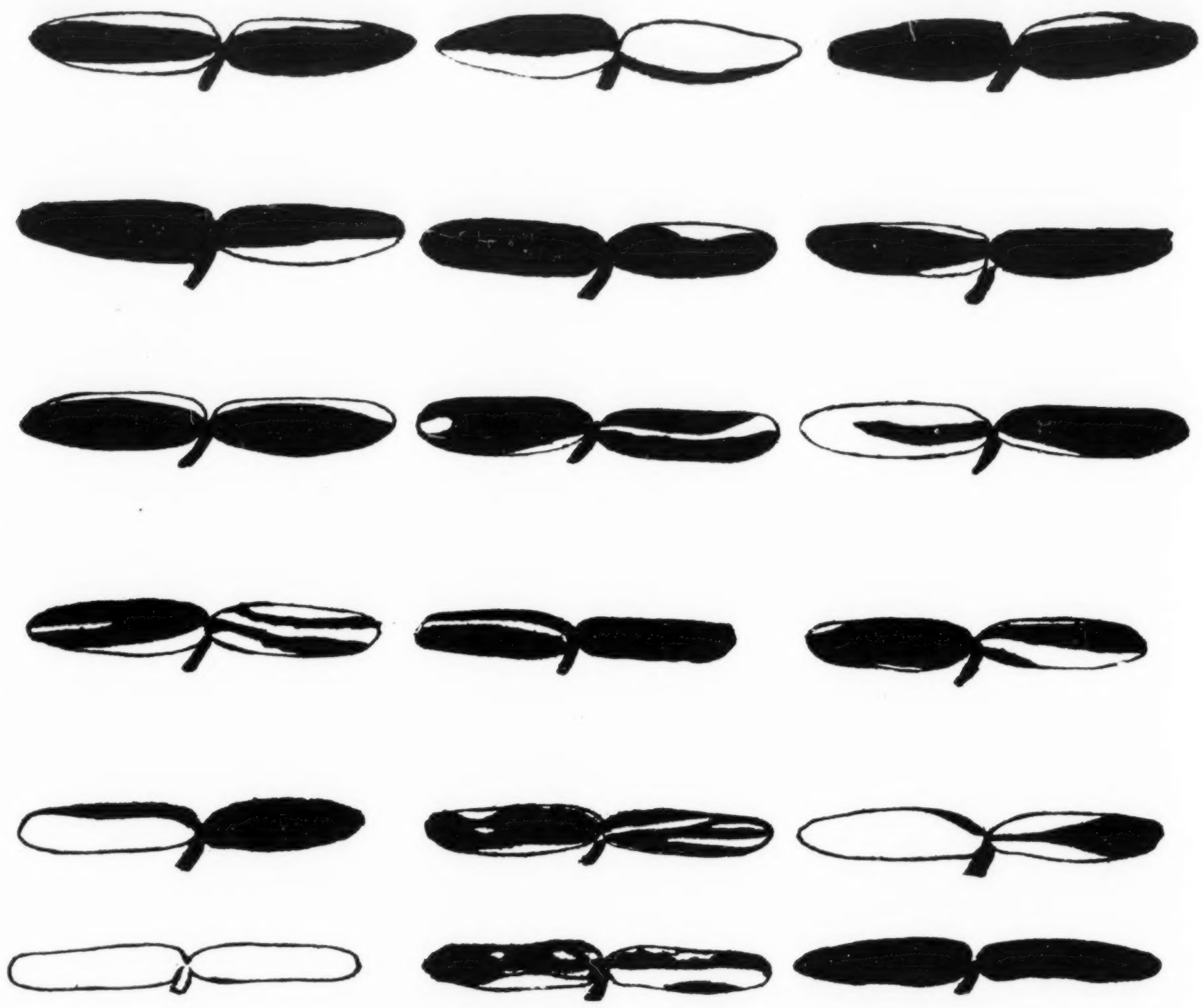
(b) "Chlorina" and "Pallida" types. Leaves have less chlorophyll than normal. Leaf color fairly uniform.

3. Atypical Mendelian Types. Represented by the "Variegata" form of *Mirabilis jalapa*—Correns (10).

4. Non-Mendelian Types.

(a) "Albomaculata" type. Variegated leaves. Inheritance through the mother. No segregation in the F_2 generation.

(b) Sectorial and periclinal chimeras.



VARIATION IN PIGWEED CHIMERA SEEDLINGS

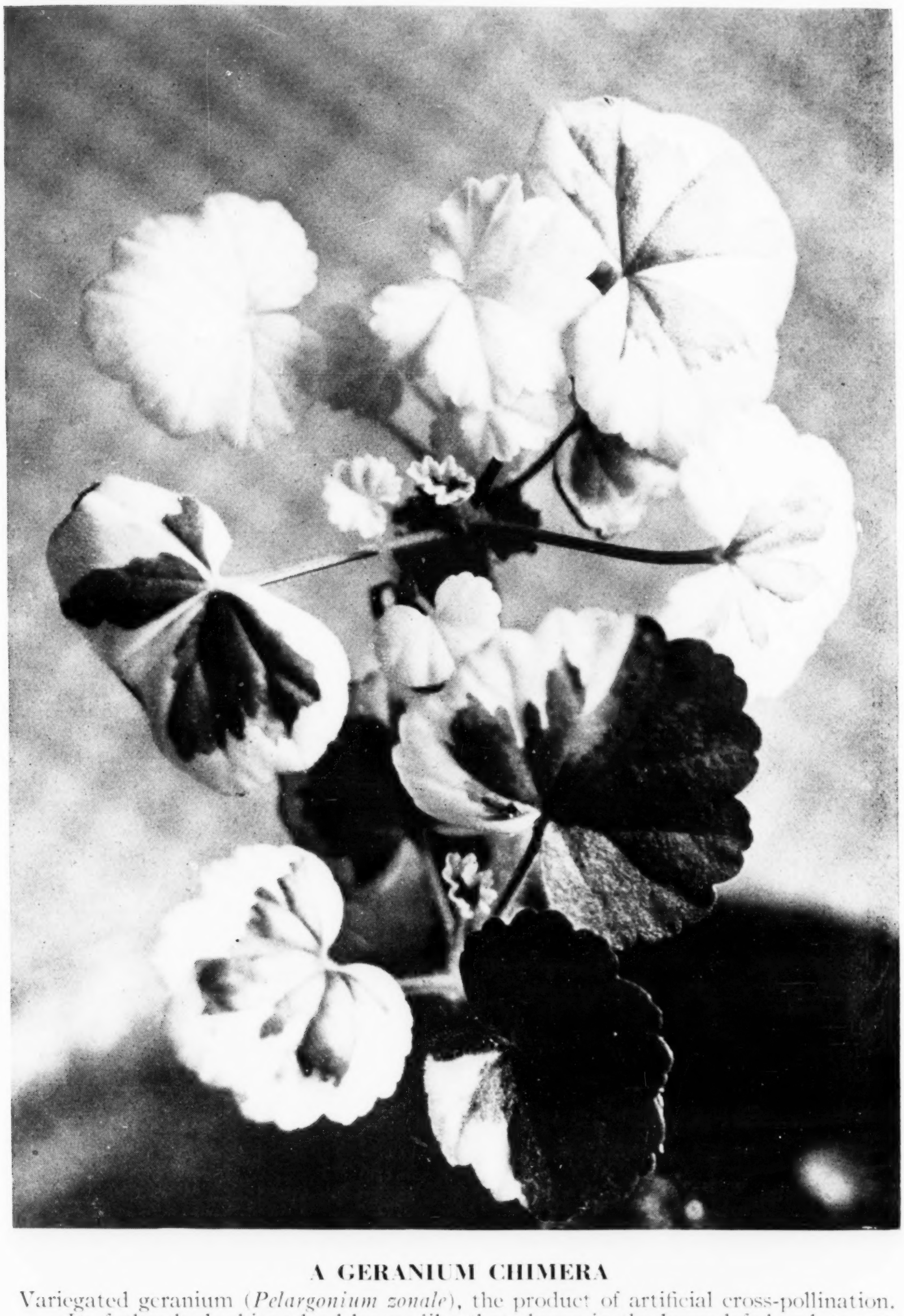
Seeds of the green and white pigweed chimera as shown in the frontispiece were planted and produced about three-fourths green and one-fourth white plants. A few of the plants were variegated, and it is believed that these were produced by the union of germ cells from green tissue and germ cells from white tissue. The patterns of the cotyledons of these variegated seedlings are shown in the above diagram, a pure white and pure green plant being sketched in the lower corners, for comparison. The heredity of these seedlings does not follow any mathematical law for the plants as a whole, but the relative number of white and green seedlings produced by a chimera depends largely on the ratio of white to green tissue. (Fig. 10.)

INFECTIOUS CHLOROSIS.

Under this heading Baur (1 and 2) describes a peculiar disease among Abutilons and other plants in which the leaves are green with white spots. The disease may be transferred to healthy green leaved plants by grafting, but in no other way. Healthy plants are not infected by contact with spotted plants even when grown together in the same pot. Baur was also unable to infect healthy plants by injecting them with tissue juices of chlorotic individuals and for this reason he believes that it is not a germ disease, although its ability to spread from plant to plant by grafting would lead one to suppose so. It seems to me possible, however, that the disease is due to an organism which lives in the vascular ducts and is so delicate that it is killed by the cell juices when the tissues are crushed. Infectious chlorosis is not inherited. Seedlings from infected plants are all green and normal.

CHLOROPHYLL ALBINOS.

The Mendelizing forms which lack chlorophyll entirely cannot be used in crosses because of their early death. We know of their existence only through the behavior of green or yellowish-green



A GERANIUM CHIMERA

Variegated geranium (*Pelargonium zonale*), the product of artificial cross-pollination. Its father had white-edged leaves like that shown in the lower left-hand corner, its mother had normal green leaves. The same cross produced plants which were apparently pure green and others which were apparently pure white, in addition to variegated plants of the type here shown. One of the upper branches of this geranium, it will be noted, is composed entirely of white tissue and so has only white leaves, while the lower branch is composed of green tissue which is partly enclosed on the left side with a thin layer of white cells. (Fig. 11.)

A CABBAGE CHIMERA

Variegated cabbage, whose heredity has not yet been put to the test of breeding. Dr. Chapin thinks it is probably a chimera showing both sectorial and periclinal variegation. (Fig. 12.)

plants which act as heterozygotes; that is, they produce green seedlings and white seedlings in the ratio of 3 : 1. Such plants have been reported by Baur (6) for Antirrhinum (Snapdragons) and Melandrium. Johannsen has also briefly reported a similar case in Phaseolus (Kidney Beans). Shull (16) has confirmed Baur's work with Melandrium.

Baur's Melandrium (6) is especially interesting. He found a wild *Melandrium album* which had one branch with a streak of white tissue on it affecting the leaves on that side. Eventually the white tissue surrounded the green, forming a periclinal chimera with white-edged leaves. A female blossom on this branch was then fertilized with pollen from a normal green plant. This was equivalent to a cross between white female and green male since the germ cells are only formed from the outer layer of cells just beneath the epidermis in the apical cone. This cross resulted in over 200 seedlings all green though a little paler than normal. When crossed with each other they produced green and white offspring in the ratio of 3 : 1. No variegated plants were produced. The question then was whether the white branch had sprung from a normal green plant or from a heterozygote for white and green. As self fertilization was impossible, flowers on the green branches were crossed with pollen from heterozygotic offspring of the white branch, produced as described, with the result that green and white seedlings were produced in the ratio of 3 : 1. If the plant had been a normal green homozygote such a cross would have produced only green plants.

Some of the earliest work on chlorophyll color was done by Baur (3) with an "aurea" form of snapdragon, *Antirrhinum majus*. The leaves of the "aurea" plants were yellowish green or golden in color and they had less chlorophyll than normal, green plants. Baur's experiments showed that the "aurea" plants were to be regarded as heterozygotes, for when self fertilized they produced green, "aurea" and yellow seedlings in the ratio of 1 : 2 : 1. The yellow seedlings soon died, as they had no chlorophyll in their leaves, but only a yellow pigment, carotin, which gave them their color. The cross between green plants and "aurea" plants gave green and "aurea" offspring in equal numbers. Evidently this case is like that of the famous Andalusian fowl.

"CHLORINA" AND "PALLIDA" TYPES.

Plants which have less than the normal amount of chlorophyll in their leaves, are true to seed and behave as typical recessives when crossed with normal green plants, have been described by Baur, Correns, Shull and others. "Chlorina" forms have been described by Baur (5, 6) for *Antirrhinum majus* (Snapdragon) and *Aquilegia vulgaris;* by Correns (9, 10) for *Mirabilis jalapa* (Four O'Clocks) and *Urtica pilulifera* and *U. dodarti* and by Shull (16) for *Melandrium*. The "pallida" type has only been reported by Shull for Melandrium. Price and Drinkard (15) report a case of yellow leaved tomatoes which appears to belong in this class.

Correns' "chlorina" type of *Mirabilis jalapa* has pale green leaves which contain 28 to 30% of chlorophyll. The plants and their flowers are smaller than usual on this account. The color seems to be fairly uniform, though it varies somewhat in different plants. In Melandrium Shull says the "chlorina" plants have about 43% of chlorophyll in their leaves. The color varies considerably in intensity in different plants and even in different parts of the same plant. They also have a tendency to bleach in strong sunlight, especially near their centers. The "pallida" type of Melandrium differs from "chlorina" in having rather darker leaves (about 65% chlorophyll) which do not fade in sunlight. The color is more uniform than in "chlorina."

THE MENDELIAN EXPLANATION.

If we let X represent the sum of all the unknown factors for chlorophyll color, then the following formulas will explain Shull's results with Melandrium.

1. XX ZZ YY NN produces normal, green leaves.

2. XX zz YY NN forms a white plant without chorophyll which soon dies because it lacks the Z factor.

3. XX Zz YY NN is green like no. 1 but differs in being a heterozygote. Its offspring are green plants and white plants in the ratio of 3 : 1.

4. XX ZZ yy NN gives the "pallida" form.

5. XX ZZ Yy NN represents the hybrid between green and "pallida." It has green leaves and produces green and "pallida" offspring in the ratio of 3 : 1.

6. XX ZZ YY nn gives the "chlorina" form. Like "pallida" it behaves as a simple recessive to normal green. The cross between "chlorina" (XX ZZ YY nn) and "pallida" (XX ZZ yy NN) produces a green leaved plant with the formula:

7. XX ZZ Yy Nn whose offspring in the F_2 generation are composed of green, "chlorina" and "pallida" plants. Theoretically the ratio should be 9 : 3 : 3 : 1, the one plant in 16 being a new type of the formula:

8. XX ZZ yy nn which Shull calls "subchlorina." Unfortunately he was unable to distinguish the "subchlorina" plants from the others. The number of green and pale leaved plants agreed very well with the expected ratio of 9 : 7, however.

Baur (6) says that a factor Z is necessary for the production of chlorophyll. Plants which do not possess it are pure white and cannot live. Factor Y is only active in the presence of Z. Plants with Z but not Y are yellow and cannot live. Factors Z and Y without N produce the pale green "chlorina" color. Factor N produces a green plant in the presence

PROBABLY A CASE OF INFECTIOUS CHLOROSIS

One of the causes of variegated leaves in plants is infectious chlorosis, a disease which is not inherited, but transmitted only by grafting. The leaf of *Farfugium grande*, here shown natural size, appears to be thus infected. The spots start from the small capillary veins and enlarge radially. "The white spots are surrounded by a border of yellowish green where the chloroplasts are losing their color," Dr. Chapin notes. "One gets the impression that the green cells are being bleached by a poison which diffuses slowly from centers scattered about the leaf, and it is hard to account for this except by the parasitic theory." (Fig. 13.)

of at least one Z and two Ys. The formula ZZ Yy NN gives "aurea" plants.

It should be borne in mind that the Z, Y and N factors in Melandrium are not necessarily the same as those in other plants, such as Antirrhinum. Baur and Correns seem to think that the inheritance of chlorophyll color is connected directly with the inheritance of the yellow pigment, carotin. Shull, however, on the basis of his work with Melandrium, believes that they are due to independent factors.

ATYPICAL MENDELIAN TYPES.

In the "variegata" form of *Mirabilis jalapa*, Correns (10, 12) shows a very puzzling type of heredity. This race of Four O'Clocks differs from the "chlorina" type in having patches of pure green scattered over a background of "chlorina" color on the leaves. The number and size of these spots varies greatly in different plants and fluctuates to some extent from leaf to leaf. Some "variegata" plants are scarcely to be distinguished from "chlorina," the green

spots are so few and small; while on others dark green spots are large and numerous. They have about 40% of chlorophyll as compared with 30% in "chlorina" plants.

Here and there on "variegata" plants one finds green branches which remain green without producing variegated leaves. Such branches are more common on heavily spotted plants, but they may occur on any though some may not happen to produce them. Branches with pure "chlorina" colored leaves might be expected, but they are not mentioned and apparently do not occur. "Variegata" plants are not true to seed. The variegated branches produce

1. "Variegata" plants between 90 and 100%.

2. Green heterozygotes, a few, whose offspring are green and "variegata" plants in the ratio of 3 : 1.

3. Green homozygotes, a few, with only green offspring. The green branches on "variegata" plants behave as heterozygotes producing green and "variegata" seedlings in the ratio of 3 : 1. "Variegata" is recessive to green and dominant to "chlorina," the F_2 generation segregating in each case in the usual 3 : 1 ratio. Correns gives the following Mendelian interpretation:

Green (G) is dominant over "variegata" (V) and both are dominant over "chlorina" (C). The genetic character of the germ cells in these plants would then be:

Green, GVC, GVc, GvC or Gvc.
"Variegata" gVC or gVc.
"Chlorina," gvC.

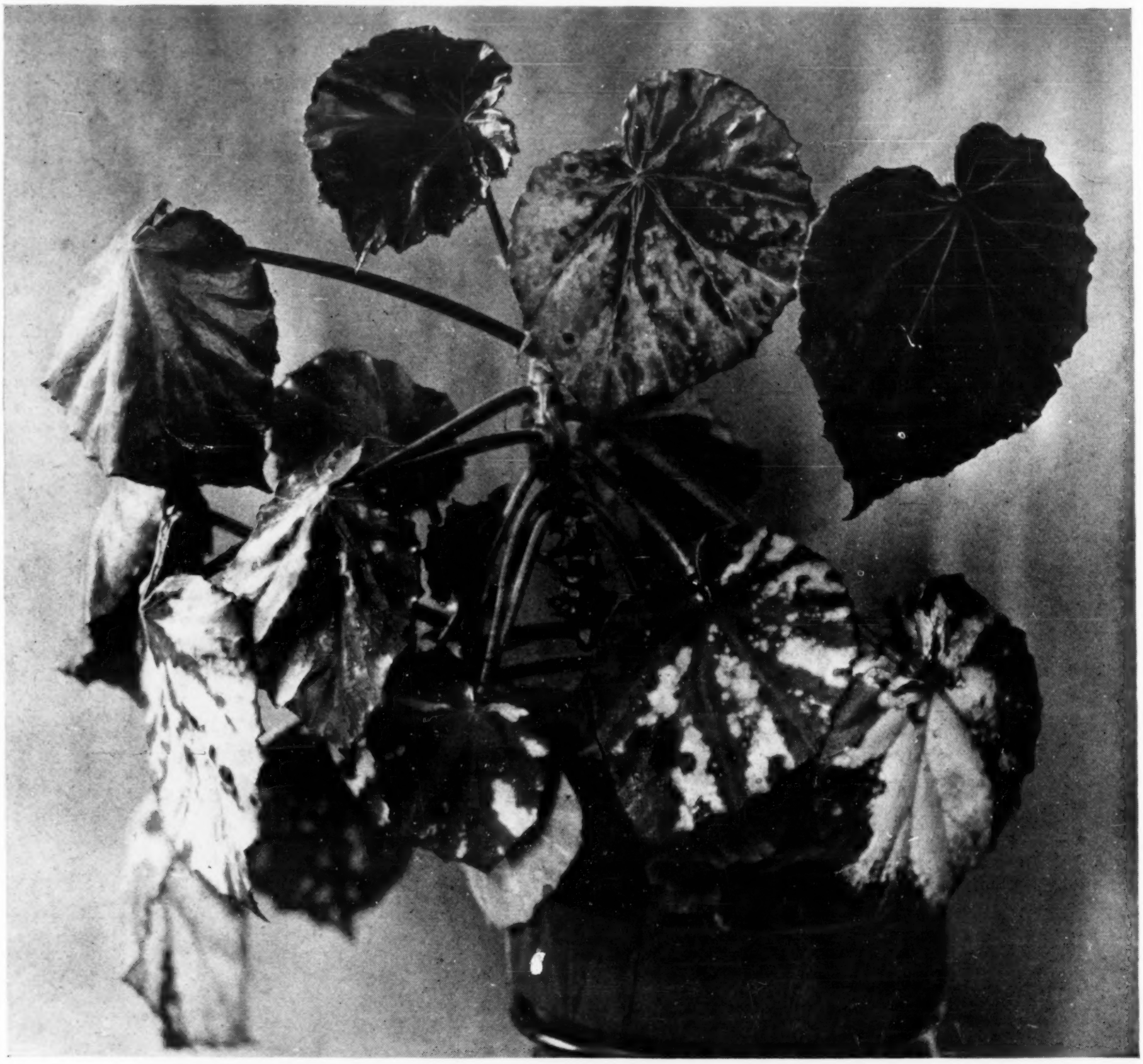
He reports the results of a few crosses between green plants whose germ cells had the constitution (GvC) and "variegata" (gVC). The F_1 plants were all green (GgVvCC). The F_2 plants had germ cells GVC, GvC, gVC and gvC in equal numbers, which gave green, "variegata" and "chlorina" seedlings in the ratio 12 : 3 : 1. A Punnett square may make this clearer to those who are unfamiliar with Mendelian ratios. In this square the male germ cells are placed above the diagram and the female cells along the left side. The nature of the plant formed by the union of any two cells is shown in the small square where the columns intersect.

MALES

FEMALES	GVC	GvC	gVC	gvC
GVC	GGVVCC Green	GGVvCC Green	GgVVCC Green	GgVvCC Green
GvC	GGVvCC Green	GGvvCC Green	GgVvCC Green	GgvvCC Green
gVC	GgVVCC Green	GgVvCC Green	ggVVCC "Variegata"	ggVvCC "Variegata"
gvC	GgVvCC Green	GgvvCC Green	ggVvCC "Variegata"	ggvvCC "Chlorina"

In this experiment Correns obtained 106 green plants in the F_1 generation. Ten of these, self fertilized, gave in the F_2 generation 360 green, 76 "variegata" and 28 "chlorina" plants, which agrees well with the theoretical expectation of 348 green, 87 "variegata" and 29 "chlorina."

The formation of green branches and the fact that the variegated branches are not true to seed is the difficult thing to understand about these plants. Correns suggests that they are really in a continual state of change from the homozygotic, "variegata" condition to the heterozygotic, green condition, but this hardly explains anything. It is simply stating the facts in another way. And it may be questioned whether a "variegata" plant which is constantly



SPOTTED VARIEGATION IN A BEGONIA

Not a chimera, but a plant probably suffering from infectious chlorosis. Its offspring, if produced by seed, will be normal; while if it were a periclinal chimera, as it appears at first sight, its parti-colored condition would be inherited. The spots on the leaves here start from time to time at a distance from the large veins and spread until they fuse together. The nature of the disease is not yet altogether clear to scientists. (Fig. 14.)

producing a small percentage of green plants should be considered a homozygote in the strict sense of the word.

Baur's (8) "variegata" type of snapdragon differs from this in the fact that it is true to seed, no green plants being produced. Normal green is dominant to this type of "variegata" and both are dominant to "chlorina." The F_2 generation splits in each case in the common 3 : 1 ratio. Baur's explanation is briefly this:

1. A factor, A, makes the green spots of "variegata" possible even in the absence of a second factor B.

2. A factor, B, makes a uniform green color possible even in the absence of factor A.

Then aaBB are green plants true to seed.

AAbb are "variegata" plants true to seed.

aabb are "chlorina" plants true to seed.

This theory agrees with the facts except for the cross between green and "variegata" in which the F_1 plants would be AaBb. They should then form germ cells with the factors AB, Ab, aB and ab in equal numbers and

VARIEGATED GERANIUM LEAVES

The group at the left is from a seedling whose father was a periclinal chimera with white edged leaves and whose mother was a green-leaved plant. The three leaves in the center are from three different periclinal chimeras. The two leaves at the right show a reversal of the usual condition in periclinal chimeras of the geranium. Here the green tissue is on the outside and the white inside. (Fig. 15.)

the F_2 seedlings would then be green, "variegata" and "chlorina" in the ratio 12 : 3 : 1 instead of the actual ratio of 3 green to 1 "variegata." To account for this Baur assumes that factor coupling occurs so that instead of all four types of germ cells being formed, the F_1 plants produce only two having the formulas Ab and aB. Just why Baur did not make use of Correns' factors G, V, and C which would seem to answer the purpose equally well without the assumption of factor coupling is not exactly clear.

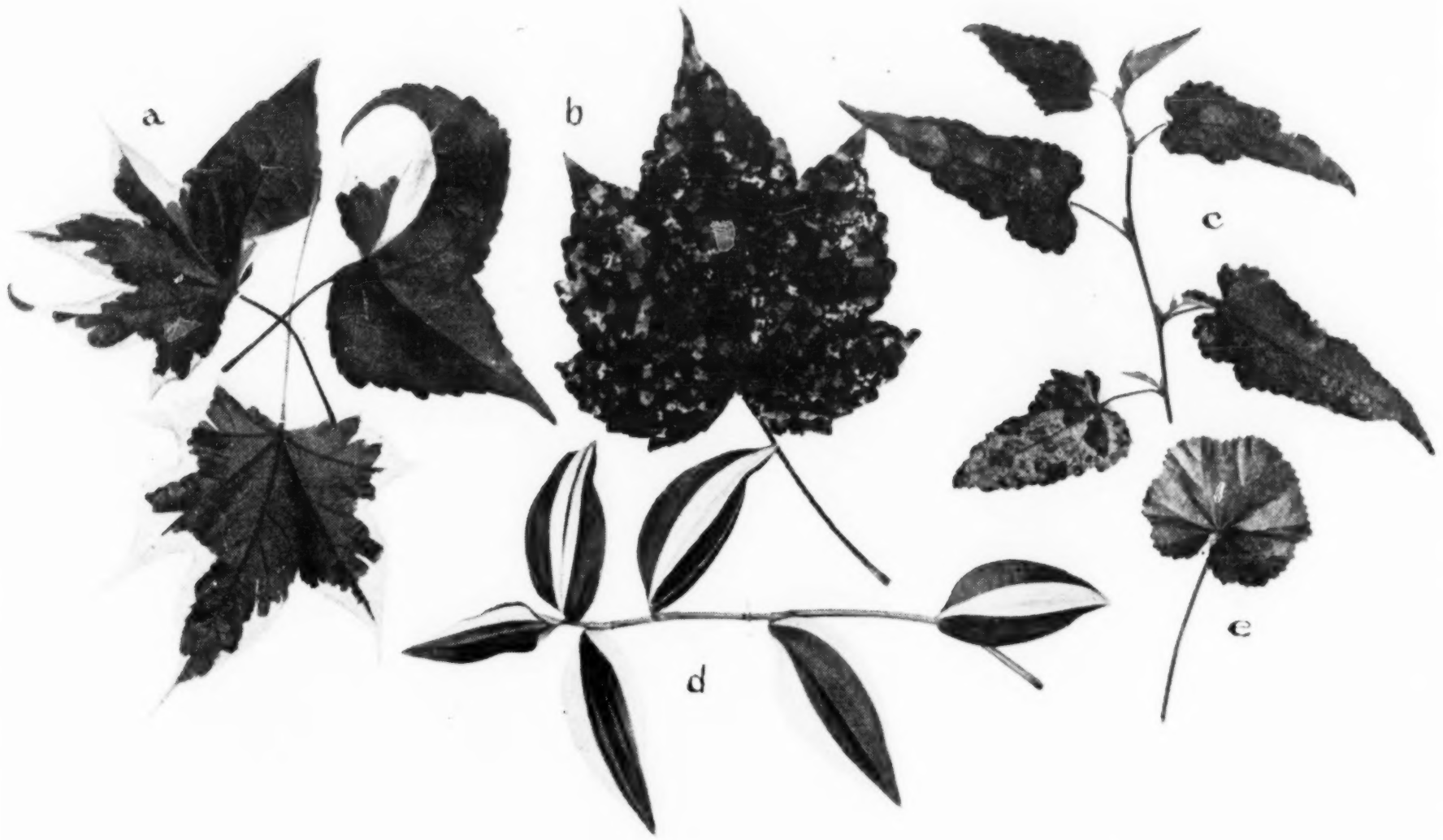
NON-MENDELIAN TYPES.

Instances of heredity which are to be explained without the use of Mendelian formulas are so rare that the following types of inheritance possess an unusual interest.

The "albomaculata" type has been described by Correns (11) for Four O'Clocks, and by Baur (7) for Snapdragons. The plants have variegated leaves irregularly spotted green and white. Some leaves are nearly white with the green spots few and small while others are nearly green with little white. All graduations of color exist between these. There are also branches with pure white or pure green leaves which do not become variegated afterwards. Anatomically it is seen that the chloroplasts are bleached out more or less in the white areas and the change from green to white spots is a gradual one. Chloroplasts may even be unequally bleached in the same cell.

The green branches produce green offspring which are true to seed. White branches yield only white seedlings which soon die. Variegated branches produce, in addition to these, "albomaculata" plants which live or die according to whether they have or have not sufficient chlorophyll to sustain life. The ratio of green, white and variegated offspring from variegated branches is different in different plants, but still it seems to bear a direct relation to the amount of green and white in the leaves.

The pollen from "albomaculata" plants behaves in crosses as if it came from normal green ones. For instance the pollen from a blossom on a white branch of an "albomaculata" plant was used on castrated flowers of a "chlorina" plant. The F_1 plants were all green with green and "chlorina" seedlings in the ratio of 3 : 1. No "albomaculata" plants appeared. Likewise no segrega-



A VARIEGATED COLLECTION

(a) Abutilon, a periclinal chimera whose green leaves have white edges. In the upper leaves the envelopment of the green by the white tissue is not complete. The misshapen leaves show that the outside skin of white tissue exerts a restraining influence on the growth of the normal and more vigorous green tissue. (b) and (c) show other abutilon leaves, spotted but probably as the result of infectious chlorosis because they are certainly not chimeras. (d) is the Wandering Jew (*Tradescantia fluminensis*), a good example of sectorial chimera. It is remarkable for the fact that the guard cells of the stomata—the breathing pores of the leaf—always contain green granules of chlorophyll even if situated over white tissue, or on pure white leaves. This is not the case in the variegated pigweed or geraniums. (e) Leaf of the Small Mallow (*Malva rotundifolia*), a common weed. The light areas are pale green, not white. Some leaves on the plant are wholly dark green while others are wholly light green. It appears to be a sectorial chimera formed partly of pale green "chlorina"-like tissue and partly of normal dark green tissue. Heredity undetermined. (Fig. 16.)

tion in the F_2 generation occurs when the pollen of "albomaculata" plants is used on the blossoms of green plants, both the F_1 and the F_2 plants being green. On the other hand, when the pollen of green plants is used on "albomaculata" blossoms the result is exactly the same as if the flowers had been self fertilized.

Correns' theory is that the "albomaculata" character is due to a disease of the cytoplasm which does not affect the nucleus. The nuclei in these plants are supposed to carry factors necessary for chlorophyll formation like those of normal green plants. No cytoplasm, however, is carried into the egg cell by the male gamete, but only nuclear materal. So the condition can only be transmitted by the mother plant and apparently the female cells of the "albomaculata" plants may be affected to a variable extent, or not at all, which accounts for all the facts.

SECTORIAL CHIMERAS.

Our knowledge of the heredity of white and green leaved chimeras rests largely on Baur's (4) work with geraniums. Such plants with grayish green leaves with white edges are familiar to every one while the reverse type whose leaves have white or pale green centers and green edges is only a little less common. In these plants, as has been said, the embryonic tissue in th

apical cone is made up of two sorts of cells, one of which produces green tissue and the other only white. In the sectorial chimeras pure green or pure white branches are frequently formed from buds starting in green or white tissue. Periclinal branches arise from the overgrowth of one tissue about the other.

The heredity of these plants involves two difficulties:

1. Why the union of green and white germ cells does not produce Mendelian heterozygotes.

2. Why such a cross should sometimes produce variegated chimeras and at other times give rise to green or white plants.

Baur's answer to the first question rests on the fact that the chloroplasts have a heredity independent of the cells in which they live. Chloroplasts originate from the division of other chloroplasts and in no other way. This does not mean that mature chloroplasts are to be found in embryonic or sexual cells, but only that small bodies which develop into chloroplasts are there and that these small mother chloroplasts are not produced from the cytoplasm or chromatin, as was formerly thought.[1]

In the previous cases of abnormal chlorophyll development which we have studied we must suppose that the normal production of green leaves is prevented by the absence of useful factors or, in the case of the "albomaculata" plants, by the presence of inhibiting agents, acting on the chloroplasts. In the white tissue of the chimeras, however, the chloroplasts themselves are abnormal and will not properly develop. The union of white and green gametes results, then, in a zygote which contains at least one white and one green mother chloroplast. These divide into daughter chloroplasts which are distributed among the dividing cells at random. Baur assumes that cell division at first takes place more rapidly than chloroplast division so that eventually at an early stage in the growth of the embryo all the chloroplasts in each cell will be descended from a single mother chloroplast, white or green.

The second difficulty Baur answers by saying that the white and the green seedlings are probably extreme types of chimeras in which the apparently missing green or white tissue is represented by only a few cells which escape notice with the naked eye. He says he has been able to find small islands of white or green cells in seemingly pure green or pure white seedlings, though whether they are present in all cases he is, of course, unable to say.

According to this theory we would expect that the extreme types, the all green and the all white seedlings, would be rather scarce as compared with the variegated plants, instead of the heavy majority of green seedlings which Baur's figures show. In my own crosses variegated plants have always been in the minority, though in one case the white plants outnumbered the green. This is doubtless due to some unknown factors in the mechanism of development.

A good start has been made in the study of chlorophyll inheritance, but much remains to be done. Several of the theories given rest on the shaky foundation of few observations and small numbers. A discovery is hardly a discovery until others have repeated the work with the same results. The great importance of this work is seen when we remember that the welfare of all the higher forms of life depends ultimately on the work of the chloroplasts.

SUMMARY.

A pigweed, *Amaranthus retroflexus*, was found having variegated leaves. The plant was evidently a sectorial chimera composed of green and white tissue. Its offspring consisted of green, white and a few variegated seedlings like the mother plant. Green seedlings

[1] Ernst A. Bessey writes me: "The probability that the pollen carries over any *anlage* for chloroplasts is very slim, as it is only the two male nuclei from the pollen tube that seem to be essential, and only one of them enters the egg. These nuclei slip out of the cytoplasmic sheath way up in the style so that they simply enter into the fertilization as naked nuclei and not as in the lower plants, as whole cells. In some plants chloroplasts have been observed in the egg cell and in most plants where it has been investigated the *anlage* of such chloroplasts are present."

and green branches from variegated plants produced only green offspring. White branches produced only white offspring when self fertilized. Cross fertilization was not attempted. It is likely that the variegated plants which do appear come from a cross between green and white gametes. Probably the heredity of this plant belongs to the type of variegated chimeras of *Pelargonium zonale* described by Baur (4).

In conclusion I wish to express my thanks to Dr. Ernst A. Bessey and Prof. Henri Hus for their helpful encouragement and many valuable suggestions.

REFERENCES.

BAUR, ERWIN.

1. Zur Aetiologie der infektiösen Panachierung. Ber. d. Deutsch. Bot. Ges. 22, 1904, p. 453.
2. Uber infektiöse Chlorosen bei Ligustrum, Laburnum, Fraxinus, Sorbus und Ptelea. Ber d. Deutsch. Bot. Ges. 25, 1907, p. 410.
3. Untersuchungen über die Erblichkeitsverhältnisse einer nur in Bastardform lebensfähigen Sippe von *Antirrhinum majus*. Ber. d. Deutsch. Bot. Ges. 25, 1907, p. 442.
4. Das Wesen und die Erblichkeitsverhältnisse der "Varietates albomarginatae hort." von *Pelargonium zonale*. Zeitschr. f. ind. Abstamm. und Vererb. 1, 1909, p. 330.
5. Vererbungs- und Bastardierungsversuche mit Antirrhinum. Zeitschr. f. ind. Abstamm. und Vererb. 3, 1910, p. 34.
6. Untersuchungen über die Vererbung von Chromatophorenmerkmalen bei Melandrium, Antirrhinum und Aquilegia. Zeitschr. f. ind. Abstamm. u. Vererb. 4, 1910, p. 81.
7. Einführung in die experimentelle Vererbungslehre. Berlin, 1911.
8. Vererbungs- und Bastardierungsversuche mit Antirrhinum. II. Faktorenkoppelung. Zeitschr. f. ind. Abstamm. u. Vererb. 6, 1912, p. 201.

CORRENS, CARL E.

9. Über Bastardierungsversuche mit Mirabilis-Sippen. Ber. d. Deutsch. Bot. Gesell. 20, 1902, p. 594.
10. Vererbungsversuche mit blass-(gelb) grünen und buntblätterigen Sippen bei *Mirabilis jalapa*, *Urtica pilulifera* u. *Lunaria annua*. Zeitschr. f. ind. Abstamm. u. Vererb. 1, 1909, p. 291.
11. Zur kenntnis der Rolle von Kern und Plasma bei der Vererbung. Zeitschr. f. ind. Abstamm. u. Vererb. 2, 1909, p. 331.
12. Der Übergang aus dem homozygotischen in einen heterozygotischen Zustand im selben Individuum bei buntblätterigen und gestreift blühenden Mirabilis-Sippen. Ber. d. Deutsch. Bot. Ges. 28, 1910, p. 418.

MOLISCH, H.

13. Über die Panachüre des Kohls. Ber. d. Deutsch. Bot. Ges. 19, 1901, p. 33.

NILSSON-EHLE, H.

14. Einige Beobachtungen über erbliche Variationen der Chlorophylleigenschaft bei den Getreidearten. Zeitschr. f. ind. Abstamm. u. Vererb. 9, 1913, p. 289.

PRICE, H. L. AND DRINKARD, A. W. JR.

15. Inheritance in Tomato Hybrids. Virginia Agr. Exp. Sta. Bull. No. 177, 1908.

SHULL, GEO. H.

16. Über die Vererbung der Blattfarbe bei Melandrium. Ber. d. Deutsch. Bot. Ges. 31, 1913, p. 40. Generalversammlungsheft.

Eugenics and Genius

If anyone could devise for us a means by which the genius, potentially existing at any time, were realized, he would have performed in effect a service equivalent to that of which eugenics repudiates the present possibility—the actual creation of genius. * * * But if eugenics can raise the average level of human intelligence, in so doing not merely does it render more likely, as Mr. Galton points out, the production of men of the highest ability, but it provides those conditions in which men of genius, now swamped, can swim. We could not undertake to produce a Shakespeare, but we might reasonably hope to produce a generation which would not destroy its Shakespeares. And even if men of genius still found it necessary, as men of genius have found it necessary, to "play to the gallery," they would play, as Mr. Galton says of the demagogue in a eugenic age, "to a more sensible gallery than at present."—C. W. Saleeby: Parenthood and Race Culture (1909).

STUDIES IN HUMAN HEREDITY

Many Investigations Under Way in United States, Some of Them on a Very Large Scale—What the Investigators Are Doing—Help Wanted from Members of This Association.

DR. FREDERICK ADAMS WOODS DR. ADOLF MEYER
CHARLES B. DAVENPORT
Eugenics Research Committee of the American Genetic Association.

THE amount of research in human genetics and eugenics, now being carried on in the United States, is probably realized by few persons. In the following report, the Eugenics Research Committee of this Association has brought together data about some of these lines of investigation. The report does not include all such lines, or even all the important ones. It is probable that many investigaters unknown to this committee are pursuing researches in different parts of the country; the committee hopes they will send to the JOURNAL OF HEREDITY brief statements of their work, in order that all those interested may know just what is being done, and what remains to be undertaken.

The object of the committee in presenting this report is twofold. In the first place, it is felt to be a matter of interest to genetists, both here and abroad, to know just what is being attempted in this branch of the science in the United States. In the second place, it is hoped that members of this association who know where valuable material may be found bearing on human heredity, but can not make use of it themselves and do not know to whom they may refer it, will be able with the help of this report to communicate with some one engaged on a similar line of research, letting him know where new material of interest to him can be obtained. If all who know of family histories including striking cases of the inheritance of twinning, left-handedness, feeblemindedness, congenital deafness, longevity, or a dozen other easily recognized traits, will communicate the fact to some worker in that field, it will immediately bring to light many new and valuable pedigrees which under present conditions are likely to remain buried for a long time.

The following report does not, for the most part, take into account investigations that have been made at some time in the past, and completed or given up before completion. It also omits many individuals who have conducted research work in the past, but are believed not to be actively engaged in such work at present. Workers are mentioned mainly in alphabetical order.

THE HYDE GENEALOGY.

Alexander Graham Bell, whose investigation of the inheritance of congenital deafness was the first serious study in cacogenics made in America, has just completed an exhaustive analysis of data contained in published genealogies of the Hyde family, with a view to discovering the degree of inheritance of longevity. His material embraces nearly 3,000 individuals, and the results leave no doubt that long life is largely dependent on heredity. When published, this investigation will also be an important contribution to the question of the results of early marriage, since Dr. Bell's statistics appear to show[1]

[1] C. L. Redfield's investigation seems to throw additional light on this point. From a study of 1109 cases he reports that the infant mortality is greatest among the children of old parents, but that if only children who reach maturity are counted, the longevity is proportional to the age of parents, the longest-lived children being those born when their parents were far past youth. "Taking the tables for longevity and infant mortality together, it will be seen that the children of young parents are more likely to survive to maturity than the children of old parents, but of those which do survive, the children of old parents live longer than those of young parents." (Dynamic Evolution, 1914, p. 185).

that the younger the parents at birth of an individual, the greater that individual's chance of long life. This correlation extends almost to the physiological limit at which reproduction becomes possible.

In order to continue the investigation of inheritance of longevity, Dr. Bell has founded the Genealogical Record Office, at 1601 Thirty-fifth street, northwest, Washington, D. C., where large numbers of genealogies are being gathered which include cases of long life in several generations; as rapidly as these accumulate in sufficient quantity, they will be subjected to analysis.

In addition to this strictly eugenic investigation, Dr. Bell is continuing his cacogenic researches, by analyzing in graphical form the data contained in Fay's "Marriages of the Deaf." The results leave no room for doubt that the most frequent cause of congenital deafness is heredity, and that if the congenitally deaf are allowed to intermarry, there is danger, as Dr. Bell pointed out more than a generation ago, of the formation of a deaf variety of the human race in the United States. The figures do not, however, bear out the statement often made by those who have not investigated the subject personally, that marriages between congenitally deaf persons invariably result in the production of deaf offspring.

The Volta Bureau of Washington, D. C., of which Dr. Bell is the founder, has on hand and is constantly adding to the largest collection of data in the world in regard to the inheritance of deafness. This includes the results of two special censuses made by the United States government, and has never been properly analyzed. Any investigator wishing to undertake a piece of statistical work on heredity of the highest practical importance could probably secure access to this immense collection of data, and would find that it yielded a maximum return from a minimum amount of work.

HARE-LIP PUZZLING.

William F. Blades of the Eugenics Record Office, Cold Spring Harbor, Long Island, is making a special study of hare-lip in man, and in addition to the collection of human pedigrees, is carrying on breeding experiments with several hare-lip strains of Boston Terriers. In the dogs as in man, hare-lip and cleft-palate are found to be highly hereditary in character, but up to the present Mr. Blades has been unable to determine in what way they are inherited, the material on hand, although it is considerable in amount, seeming to be insufficient to reveal the existence of any law. The investigation is complicated by the fact that many people endeavor to conceal slight cases of hare-lip, particularly if these have been partly or wholly remedied by surgical operation. Mr. Blades welcomes inquiries concerning this condition and provides blanks for the recording of family data to anyone interested in the problem and willing to furnish any information, be it even the names and addresses of individuals who may be able to provide material at first or second hand.

Professor J. McKeen Cattell of Columbia University, New York City, has been engaged for some years on a study of the families of 1,000 American men of science. The data, which are being analyzed from many points of view, are not yet wholly ready for publication. The birth rate is the central point of the investigation; it is decidedly low among this portion of the population, and evidence indicates that this is largely due to psychological, rather than physiological, reasons. Much of Professor Cattell's work has been the detection and elimination of statistical fallacies, in which this subject particularly abounds. Even such mathematicians as Francis Galton and Karl Pearson have run into pitfalls in dealing with it; it is, then, only to be expected that investigators of lesser note should often have gone astray, and that result is found to exist in nearly all the published work.

Following is a synopsis of his work on this subject:

"The completed family of contemporary scientific men is about 2, the surviving family about 1.8, and the number of surviving children from

each scientific man about 1.6. Twenty-two per cent. of the families are childless; only one family in 75 is larger than six. The same conditions obtain for other college graduates. Answers have been received from 461 leading scientific men giving the causes which led to the limitation in the size of their families. One hundred and seventy-six were not voluntarily limited, while 285 were so limited, the cause of the voluntary limitation being health in 133 cases, expense in 98 cases and various other reasons in 54 cases. Childlessness was involuntary in two-thirds of the cases. In the standardized family of two the condition is desired in six cases out of seven. In over one-third of the families the limitation was involuntary, due to infertility and other pathological causes, but if these had not obtained, voluntary limitation would have occurred in nearly all or perhaps in all cases."

ALCOHOL AND HEREDITY.

Dr. T. D. Crothers, Director of the Walnut Hospital for Inebriates, Hartford, Connecticut, is undertaking modern field studies among the families of inebriates.

Dr. C. H. Danforth and his associates of the department of anatomy, Washington University, St. Louis, Mo., have recently undertaken the investigation of a number of lines of heredity, in which anatomy plays a part. One of the methods of operation is to examine all subjects brought to the dissecting table, for abnormalities that give promise of being due to heredity. When such are found, living relatives of the deceased are sought out, and the pedigree made up as far as possible. The problem of twinning is also being attacked, but the results so far agree with those found by other investigators, in that they show some forms, at least, of twinning to be distinctly hereditary, without giving any clear light as to the manner in which the tendency is inherited. It is found that the measure of resemblance between twins is not a safe indication whether they are homologous ("duplicate," i.e., formed by a division of the fertilized ovum at the stage when it consists of two cells) or heterologous (ordinary twins). It is possible that the two types of twinning are differently inherited.

Charles B. Davenport, director of the Department of Experimental Evolution, Carnegie Institution of Washington, at Cold. Spring Harbor, Long Island, New York, and also director of the Eugenics Record Office there, has been devoting particular attention during the last few years to the inheritance of mental traits. Many of these researches will be described in his forthcoming book, "The Feebly Inhibited," which will contain, among other first-hand field data, 165 family histories. It is a study of the nature and control of emotional impulses, with special reference to criminalistic traits, the manner of their inheritance, and their periodicity.

Under Dr. Davenport's immediate supervision, a special study in the inheritance of stature is being made by the Eugenics Record Office. The usual field studies in this office continue: at present they include a study of families that have produced many of America's most effective men, with special reference to the origin of their distinctive traits; and a further study of the Jukes family, that famous cacogenic group in the state of New York, which Dugdale brought to light 40 years ago. A. H. Estabrook, who unearthed the history of the "Nam" family, a somewhat similar group, a few years ago, has taken up the present status of the Jukes, in order to observe the changes that have taken place in them as they have become scattered over the country during recent years. It is interesting to find that a few branches which are far from the original environment have produced excellent and prosperous citizens—possibly as the result of some fortunate marriage in the previous generation. On the whole, however, this great tribe continues to furnish an almost unparalleled record of continuous inefficiency, from a social point of view.

CONSANGUINEOUS MARRIAGE.

The study of consanguineous marriages and their consequences, as observed

on the Maine coast, has been undertaken for the Record Office by Miss Mary M. Sturges, who previously investigated the same subject in isolated parts of Long Island. As the families dealt with are characterized by various defects, it is found, as was expected, that these are manifested in an intensified form, as the result of cousin-marriages, although it is generally agreed that such matings are quite proper if made in an untainted stock.

The study of the inheritance of Huntington's chorea is being carried on by Dr. Elizabeth B. Muncey, who has traced this condition, which behaves as a definitely dominant trait, back as far as the witches of Salem, at least one of whom in the strain it seems justifiable to chart as choreic. Family histories are being collected by field workers in 10 or 12 institutions for the feeble-minded, the insane, the epileptic, the alcoholic, the delinquent, etc. The documents thus collected, and also the contents of some printed genealogical and historical works, are being indexed by name, place and trait, in the Eugenics Record Office, and are accessible to serious investigators at any time. Schedules for a record of family traits are also distributed to all who will undertake to fill them out and return to the Record Office for permanent custody; in cases where it is requested, a duplicate schedule is sent to be retained by the person interested. Members of this Association are urged to assist in the collection of data by sending for and filling out such schedules. The Record Office also distributes, upon request by persons who are contemplating marriage, special schedules upon which they may record their family traits and which they may submit to the Record Office for comments with reference to the expectation of the traits of the offspring.

The Fifth Annual Training Class for Field Workers was held at the Record Office from July 1 to August 12 this year. It has been found that about one-half of the members of these training classes become field workers in some branch of the investigation of heredity in man. Usually the class numbers from 20 to 35 each year.

Dr. H. H. Goddard and his associates at the Training School (Vineland, N. J.) are now devoting all their time to working up material already on hand; the institution has no field workers out at present, since the amount of data awaiting analysis is already larger than can be handled. Dr. Goddard has just published a book (Feeble-mindedness, its Causes and Consequences) which gives the result of a study of the family history of 327 inmates of the Training School, in such full form as to furnish data for any future investigators who may differ from Dr. Goddard's conclusions.

FEEBLE-MINDEDNESS.

It is found that heredity alone explains about two-thirds of the cases of feeble-mindedness; the other third are due to such causes as accident, or sickness during childhood. This last cause is one which demands, and is now receiving, further study. Of a dozen children who have scarlet fever, for instance, 11 recover unscathed; the twelfth remains feeble-minded for life. The question at once arises, why was the one singled out in this way? and the apparent conclusion is again, heredity. It is found that the family histories of such children nearly always show weaknesses, which are absent from a normal pedigree. In connection with the family history of each inmate of the Training School, his or her mental and physical condition are carefully investigated, and studies also made on the metabolism, a biochemist and several assistants being kept busy on this work. It is found that feeble-mindedness (or at least, the lower grades of it) is not merely a mental defect, but that it indicates that the patient's physical condition is abnormal, as well. Extended research on this line may lead to the establishment of physiological tests to supplement the psychological ones now used to classify feeble-minded patients.

Among the family histories on hand at the Training School and awaiting publication is one embracing the group in northern New Jersey well known

under the name of "the Jackson Whites," and formed by an amalgamation of the white race with the negro and the American Indian, early in the last century. Detailed analysis of this unusual racial mixture will certainly prove of great interest to genetists; but one fact which already stands out prominently seems to be the very limited effect of environment, in influencing this mixed heredity. The socially degenerate group has spread to many points in the East, including cities and small towns; but wherever its members appear, they carry with them the "Jackson White" characteristics. It is clear, then, that their physical, mental and social condition can not be ascribed to any environmental factors, but that their deficiencies are to be explained, for the most part, by bad heredity.

In regard to the inheritance of feeble-mindedness, Dr. Goddard's data, above mentioned, convince him that it behaves as a Mendelian recessive.

MORTALITY STUDIES.

By far the most gigantic collection of data ever analyzed for the purpose which interests this Association is now being worked over in the Medico-Actuarial Mortality Investigation, which is directed by Arthur Hunter of the New York Life Insurance Company. Nearly all the prominent life insurance companies of North America are interested in this research, and have furnished details regarding 2,000,000 deaths, which are being investigated with a view to determining in what points the rates of the companies need revision. Much of the work falls outside the sphere of human heredity, but many facts have already been brought out which bear on the eugenics researches of the last decade. It is found, for instance, that the mortality is slightly *below* the average with people both of whose parents died of cancer. This, as Mr. Hunter explains, is doubtless because the policy-holders with such family histories represent a stringently selected class; the examining physicians would bar all but good risks, under those circumstances; and the result of this selection by the medical examiners is that those passed are particularly good risks, in spite of the fact that their parents died from the same malignant disease. The statistics with regard to consumption will be equally interesting: they have not been completed yet for the whole investigation, but the results of the New York Life Insurance Company are available, and probably represent the whole. It is found that in a young man or woman, a consumptive family history diminishes the expectation of longevity; but after the age of 40, the fact that an individual may have lost one member of the family through consumption has no effect whatever on the mortality. Four volumes of statistics from this investigation have already been published, and a fifth is to follow shortly.

An unusual amount of strictly eugenic research work is being carried on at the University of Pittsburgh, under the leadership of Professor Roswell H. Johnson, who offers a course entitled "Laboratory Work in Eugenics," which demands that every student entering it undertake some practical problem, usually in collaboration with the professor. Among the investigations of the past year are the following:

The inheritance of two peculiar traits in the human eye: very round eyes, and eyes closing in laughter. Both these traits, Professor Johnson says, show segregation, but apparently not on Mendelian proportions.

MARRIAGE AND BIRTH RATES.

A study has been made of alumni record books for marriage and birth rates of college graduates. This has particularly been the object of research among the graduates of women's colleges. Miss Bertha J. Stutzmann has been analyzing returns from some of the larger colleges, Miss Helen D. Murphey has tabulated the marriage and birth rates of Washington (Penn.) Seminary alumnae, and Miss Carrie F. Gilmore has been compiling facts about preferential mating in the graduates of a normal school.

A survey is also being made of the several wards of Pittsburgh, with reference to their vital and social statis-

tics, and they are being compared with wards in other American cities. Miss Sadie Scorer has been particularly engaged on the analysis of the racial contribution of these several wards.

Other problems on hand at this institution are the development of new psychometric tests for adults, a study of the geographical distribution of eminence in Europe, and a further analysis of Woods's distribution of eminence by names on a percentage basis. In all these investigations (except that with regard to the inheritance of traits in the eye which, having no social significance, is merely genetic) the viewpoint kept before the student at all times is that of actual race *betterment*, as distinct from a mere tabulation of genetic facts.

Dr. H. E. Jordan of the department of anatomy, University of Virginia, is working on the inheritance of twinning, and also of left-handedness. His data on the first subject give him ground for belief that twinning behaves as a Mendelian recessive. In regard to the inheritance of left-handedness, he said, in a recent lecture:

LEFT-HANDEDNESS.

"Left-handedness or right-handedness may be considered alternative or unit characters in a Mendelian sense. In terms of presence and absence, to which scheme the majority of Mendelian characters appears to conform, right-handedness may be conceived as dependent on the presence of the determiner in the germ-plasm, left-handedness and ambidexterity as the result of its absence. But right-handed individuals are of two sorts, those both of whose parents were right-handed, and those with only one parent right-handed. The former are said to be of duplex, the latter of simplex, condition. Those with both parents left-handed, i.e., lacking the determiner of right-handedness, are said to be nulliplex. The right-handed condition dominates or masks the left-handed condition in the hybrid generation. When left-handed mate with left-handed, all the children will be left-handed. When the determiner for a character is absent from the germ-plasm of the parent, that character can not appear in the body of the offspring. When simplex mate with simplex, one in every four will be left-handed. This is the well-known 1 to 3 Mendelian ratio for hybrid crosses with respect to a particular pair of unit characters. When simplex mate with nulliplex one-half of the offspring will lack the determiner for right-handedness and be left-handed."

Dr. Jordan further notes, "I have on hand also a considerable body of data relative to the inheritance of various types of thumb-prints, but up to the present I have not been able to make any very satisfactory interpretation of my material."

Miss Isabelle V. Kendig, late of the Monson State Hospital, Massachusetts, has recently finished an intensive study of one Massachusetts family belonging to the old American stock. The progenitor of the line left England in 1623, establishing himself at Plymouth; from there his descendants moved inland and finally settled among the hills of western Massachusetts. From that time they have begun to degenerate, and it was the object of the investigation to learn why. "There, in an isolated and unfavorable environment," Miss Kendig says, "they intermarried and multiplied, till today their blood has impregnated the entire community and rendered the town of B—— a byword for shiftlessness and poverty, for alcoholism, immorality and feeble-mindedness." The investigation well shows the danger to the commonwealth in the tendency for like mate with like, thus emphasizing and perpetuating bad characteristics which, in an environment that allowed more out-crossing, might disappear.

MARRIAGE SELECTION.

Dr. Wilhelmina E. Key of the State Institution for Feebleminded at Folk, Pennsylvania, has nearly completed the study of a Pennsylvania family of more than 1,800 individuals, about half of whom are in the direct line of descent from two pairs of German immigrants of over a century ago; the remainder were studied in connection with strains into which marriage occurred. Both networks break up into widely divergent

lines which vary greatly in social efficiency, and Dr. Key concludes: "Their evolution shows the effect of marriage selection in concentrating defect and degeneracy in certain lines, and dissipating defect and introducing traits which make for increased efficiency in others." Special attention was given to the appearance in successive generations of different grades of calculating-ability, aggressiveness and perseverance, and the investigator thinks that these traits appear in conformity with Mendel's Law.

Samuel C. Kohs of Clark University, Worcester, Mass., who approaches the problem of eugenics from the psychological side, writes as follows: "My work comes, first, under the broad head of the psychology of individual differences. More specifically, however, my interest is focussed on the significance of the complex, for differential psychology as well as for mental inheritance. My studies have led me to conclude that the unconscious should be given a more prominent place in psychogenesis. Most modern psychologists recognize that conscious phenomena are but a small fraction of all psychic functioning, and that most of the important factors influencing activity, mental and physical, lie below the conscious threshold. Some of these factors are reducible to the complex as at present used in psychoanalysis.

"As we come to recognize more and more the deep significance of Semon's mnemic theory, the more are we led to believe that inherent mental ability is not as simple a structure as has been assumed by many.

"A paper attempting to deal with this problem adequately would include the following:

"(1) Discussion of the complex and its significance.

"(2) Discussion of the unconscious in relation to the dynamic forces of life activity.

"(3) Methods of diagnosing the existence of complexes.

"(4) The complex and the question of unit characters."

H. H. Laughlin, superintendent of the Eugenics Record Office, has been devoting his attention particularly to a study of the effects of sterilization in reducing the amount of caogenic breeding in the United States. He writes:

"We hope at intervals of not too long a time to publish the reports outlined in Bulletin No. 10a. The American Institute of Criminal Law and Criminology, at its recent meeting, appointed Committee H on sterilization. This committee consists of:

"Joel D. Hunter, Chief Probation Officer of Cook County, Chicago, Ill.; Father O'Callaghan and Dr. William T. Belfield, of Chicago; Judge Warren W. Foster, of New York; Dr. William A. White, of the Government Hospital for the Insane, Washington; Hastings H. Hart, of the Russell Sage Foundation, New York; and H. H. Laughlin, of the Eugenics Record Office, Cold Spring Harbor, L. I."

RESEARCH IN BALTIMORE.

The Henry Phipps Psychiatric Clinic of Baltimore, directed by Dr. Adolf Meyer, is collecting data about the ancestries of its patients, and is also collecting similar data from school children in one ward of Baltimore. An analysis of the recorded matings and their offsprings is being made with special attention to a more definite characterization of common traits and their groupings in the diverging lines of the families and especially also the weight of ontogenetic factors in the determination of the individual fate and means of analyzing the personality.

Casper L. Redfield of Chicago has been studying for many years the effect of the age of parents on the character of the offspring, particularly from an intellectual point of view. This investigation, which has led not only to a thorough study of the parentage of men of genius, but to similar studies on race horses, cattle and pedigreed dogs, has led Mr. Redfield to a belief in the inheritance of certain classes of acquired characters, and the data which he has published probably form one of the most serious contributions made to Lamarckism during the last decade or two. The practical conclusion which he reaches is that intellectual excellence

in a child depends largely on the age of its parents at its birth. Mediocrities, he believes, are likely to be produced by very early marriages, unless the preceding generations married late enough to transmit qualities which will overcome the effect of the one early marriage. Men of genius, he finds, are usually produced by parents who are well advanced in years; and when data for previous generations exist, he usually finds that the grandparents and great-grandparents, as well, were mature when they made their contribution to the race.

Dr. A. J. Rosanoff, first assistant physician at Kings Park Hospital, New York, has been engaged on a study of the distribution of insanity in the United States, and the correlation of this distribution to other conditions in the country. The number of insane persons confined in institutions, per 100,000 of the general population, varies from 67.0 in Oklahoma to 413.4 in Massachusetts. These variations appear to the investigator to be in correlation, direct or reverse, with the following factors: per capita wealth production, percentage of urban population, general prevalence of illiteracy, accessibility of institutions, intra-mural conditions as reflected in the per capita cost of maintenance, and percentage of foreign-born population. Dr. Rosanoff is also working more intensively upon the inheritance of insanity, in particular families.

THE GATZERT FOUNDATION.

The case of feeble-mindedness, which hitherto has furnished the most widely worked field for the study of human heredity in the United States, is being attacked in a slightly different way by the Gatzert Foundation of the University of Washington (Seattle, Wash.). A clinic, directed by Dr. Stevenson Smith, examines several hundred children each year and obtains their family histories, whether they be precocious, average or defective. Field workers then fill in the gaps of this history, devoting particular attention to the pedigrees of children who are found to be defective but seem to show no pathological ancestry. This investigation should serve as an invaluable parallel and "control" to the many other investigations of feeble-mindedness, in which particular attention is paid to the pedigrees which show the presence of a taint in the ancestors.

Dr. David F. Weeks, superintendent of the New Jersey State Village for Epileptics at Skillman, N. J., reports:

"The aim of the work in eugenics research at the State Village has been, since it started in 1910, to obtain a hereditary history of every epileptic patient who came to the colony—not to work up special cases, but to work up all cases. From these histories we hope to learn the laws governing the inheritance of epilepsy.

"We now have filed 672 histories; these cover anywhere from two to eight generations and from 20 to three or four hundred individuals. Each case is analyzed as to the family traits observed, the types of matings from which our patients come, as well as the environmental conditions and diseases. The traits which occur most frequently in our histories are, besides the epileptic convulsion itself, extreme nervousness, migraine, alcoholism of the periodic spree type, and bad temper. In fact, nervous conditions which show periodic loss of control all stand out prominently in our histories. The epileptic convulsion seems to behave like a Mendelian trait of the recessive type. There does not seem to be any one particular type of mating.

"Besides the regular history work we try to keep in close touch with the epileptic 'situation' in the state. We keep a register and each month make a report on the number of epileptics in the state whose names are known to us, with the kind of care they are receiving.

"We also follow up discharged cases. By means of a name index we are able to connect and show relationship between many of our patients not known to be related. We hope to work up many special cases in detail in the future, but at the same time to continue the general line of research as outlined. One special history has been worked out covering over 1700 individuals.

"The Eugenics Research Department consists of two field workers and one stenographer."

GREAT PERSONALITIES.

Dr. Frederick Adams Woods of Brookline, Mass., states the scope of his present studies as follows:

"I am continuing my investigations in positive eugenics, the origin and influence of exceptional persons and superior stocks, utilizing the easily accessible records of history and genealogy.

"I have found that in Great Britain the material welfare of the nation during the last two centuries has been greatly dependent on the presence of a few very exceptional statesmen, chiefly prime ministers. At least, it may be said that there is a strong correlation between politico-economic conditions and the character of English political leaders and that under weak and incompetent premiers the country has been visited by relative stagnation or decline. It is already statistically known that the able statesmen, for which England is famous, have been born in the upper classes. Therefore, the greater their influences are proved to be, the greater is the importance of positive eugenics. These questions of the influences of great men over their times, and the comparison of great men with mediocre, are important ones, and have, as yet, been little investigated by suitable statistical devices Such historiometric researches as have already been made indicate that the gap is very wide between the average man and the man of genius.

"The scientific productivity of a country is one measure of its intellectual life, therefore it has been thought worth while to prepare an objective list of the most eminent names in the history of science, during all times from the age of the Greeks to the present day. Such a list, with the inferences to be drawn from it, will shortly be ready for publication.

"All belief in the value of eugenics hangs upon a belief in the value of heredity over environment. Hence any research which brings to the proof a failure on the part of modified surroundings to make good its claims to strength and merit, is a weapon in the hands of the eugenist. Among exposés of this sort may be mentioned the failure of American conditions of so-called equality to make success in America any less of a family affair than it is in the caste-ridden countries of Europe. In an article 'Heredity and the Hall of Fame,' published in *Popular Science Monthly*, May, 1913, the indication of this truth was given. The names in the Hall of Fame can be measured against the eminent Europeans, listed by Galton, de Candolle, Ellis, Whetham and others. Now it remains to extend the list of worthies downward from the Hall of Fame, to utilize our history and biography informing a satisfactory working list of reference and appeal, and to bring together our genealogical researches in a scientific manner.

"Some results will very shortly be ready for publication, based upon a tentative objective list of about 3,500 of the most eminent Americans, divided into several grades, showing occupations, birth-places by states, and the different degrees of relationship to others within the list. The latter ratios rise rapidly as they approach the 47 preëminent Americans who are in the Hall of Fame. The research as a whole strongly indicates the influence of heredity over environment."

Tables For Biometricians

Tables for Statisticians and Biometricians is the title of a new publication (pp. lxxxiv + 143), edited by Karl Pearson and published by the Cambridge University Press (1914) at the price of nine shillings. The book is made up of tables needed for reference by workers in the field of advanced statistics, most of which have already been printed in Biometrika. It is preceded by an extensive introduction, describing the particular purposes of the tables, and giving examples of the way in which they can be used in the solution of biological and other problems.

SKIN COLOR OF MULATTOES

Apparently Four Factors Involved—Segregation in Second Generation—Skin Pigment Developed After Birth—No Correlation Between Color of Skin and Curliness of Hair in Offspring of Mulatto Marriages.[1]

CHARLES B. DAVENPORT

Director, Department of Experimental Evolution (Carnegie Institution of Washington), Cold Spring Harbor, Long Island, New York.

THE method of heredity in negro-white crosses has long been cited as a demonstration of the failure of modern principles of heredity in their application to some specific cases. Skin color is said to show a typical blending, as in the mulatto, and it is generally assumed that all of the offspring of two mulattoes resemble their parents in skin color; and if a mulatto be crossed with a white that all of the offspring will be of a shade still lighter than the mulatto parent, namely, of a quadroon color. The current theory also has a great social importance because according to it, "once a negro, always a negro;" since the negro characteristics can not be wholly eliminated even by successive matings with white. However, as a concession, certain States even in our South permit the offspring of a person containing one-eighth negro blood and a pure white to pass as a white citizen and to marry, legally, a white person. That is, after matings of a mulatto and her offspring for two further generations with white persons the final generation may pass for white.

In order to test the theory that hybridization of skin color really does show a typical blending and failure to segregate, the author, with the assistance of a trained field agent (Miss Florence Danielson), has made measurements upon the skin color of between 600 and 700 children derived from about 200 pairs of parents and also of various other relatives. These studies were made chiefly in the islands of Bermuda and Jamaica because it was believed that the investigation would meet in those islands with fewer social obstacles. Such social obstacles were, indeed, encountered but the result justified the selection of the localities. The measurement of the skin color was made by the aid of a color top in which the proportion of black, red, yellow and white factors upon a circular disk may be varied so that, when the top is spun, any desired combination of proportions of these colors may be secured. The result of this investigation is clear cut, namely, skin color does segregate and the offspring of two strict mulatto parents may have skin color ranging from that of a pure white to quite dark in color, like that of a West Coast African negro. Segregation certainly does take place.

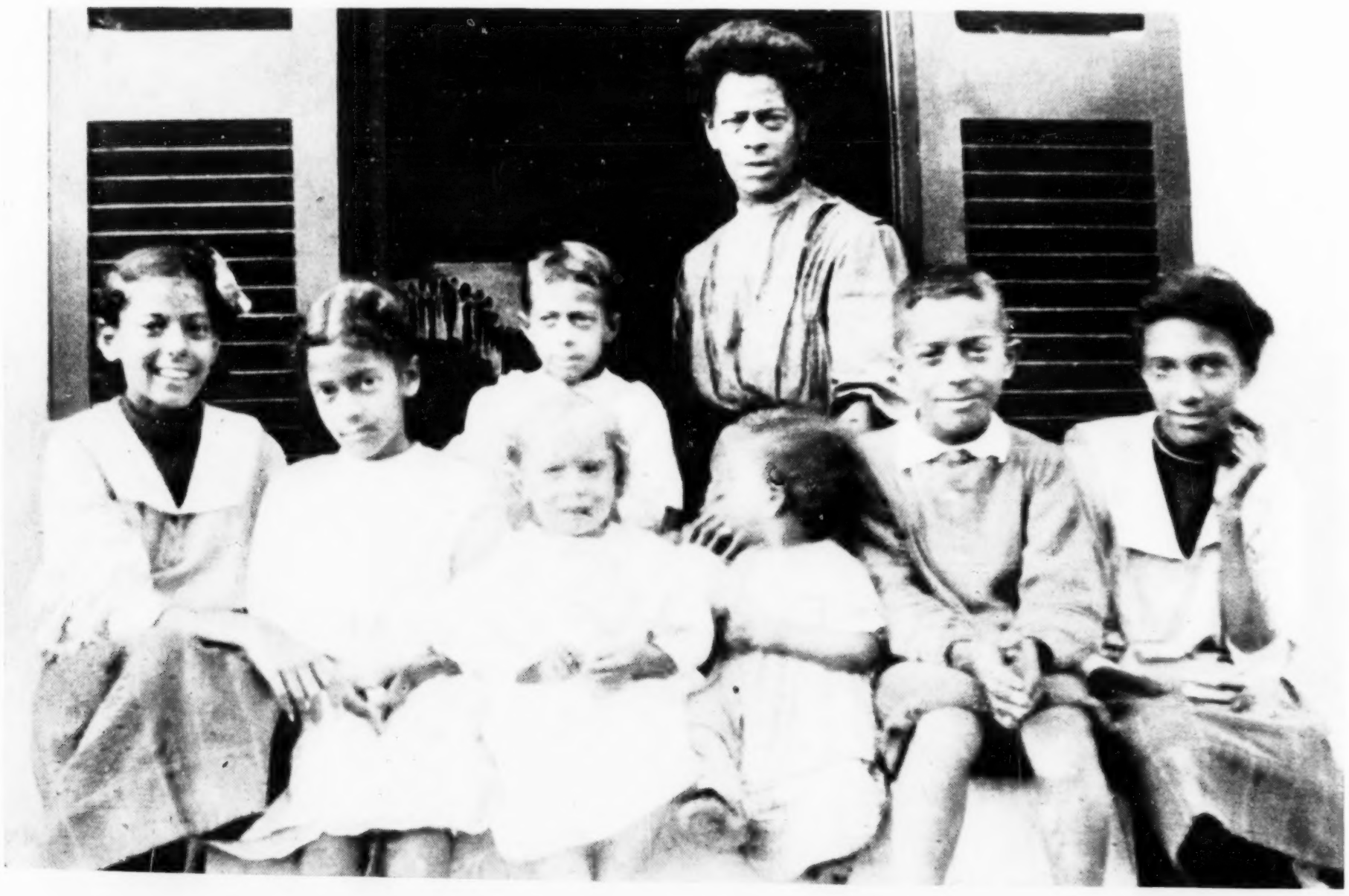
FACTORS ARE COMPLICATED.

The study shows, moreover, that the apparent blending is due to the complicated nature of the factors upon which negro skin color depends. After careful analysis of all of the results of all of the varied matings that were studied, the conclusion was drawn that in the full-blooded negro there are four factors that make for skin pigmentation and that correspondingly there are five conditions of these factors possible in the skin of the descendants of mulattoes, namely, no factor for black, one factor, two factors, three factors, or four factors for black. It follows from the fact of segregation also that the offspring of two mulattoes are much more variable

[1] This study was published in 1913 by the Carnegie Institution as publication No. 188, "Heredity of Skin Color in Negro and White Crosses." The accompanying illustrations are reproduced from that monograph.

VARIATION IN MULATTO PROGENY

The family of a white man of colored ancestry, and a mulatto woman. All seven sons and daughters are shown in the photograph. The infant is the lightest, with 8% black in the skin; this will doubtless darken with age. The son at the extreme right of the picture has 22% black in his skin; the boy at the extreme left has 26% black. (Fig. 17.)



OFFSPRING OF WHITE X MULATTO MATING

Part of the "W" family, including a medium colored mother and six of her seven children by a white man; also a little first cousin of the other children, who is directly in front of the mother. Note the great variation in the facial coloration of full brothers and sisters. The skin color of the youngest child is the same as that of a typical white infant, namely, 5% black, whereas the oldest boy of the group has a skin color of 32% black, considerably darker than his mother. (Fig. 18.)

than mulatto parents themselves. Such proves, indeed, to be the fact. Now, the white offspring of two mulattoes when mated together would seem always to give only white children. Numerous stories that are current of the reappearance of full black-skinned negro children from two white parents one of whom is of remote negro origin we could not confirm. A few stories to this effect were, indeed, current in Bermuda but they all related to matings that were made long ago and of whom the principal parties had passed away. Unless further more precise evidence to the contrary is forthcoming the current folk lore of such recurrence of full blacks to whites may be relegated to the category of "old wives' tales." The very different grades of skin color in the offspring of mulattoes correspond to a popular nomenclature, also, and in addition to white we have the quadroon, the mulattoes, the samboes (or three-fourths black), and the full black. And if the proportion of black in the whole population be considered, it will be found that, in the descendants of mulattoes, these five points represent exceptionally common positions in the general frequency curve of skin color. One of the interesting facts brought out in the investigation was the fact that the negro skin-color undergoes a clear development from birth onward during the first two years or more of life. The negro child at birth has an extremely light-colored skin, somewhat more yellowish than that of a white child. But within a few hours after the child is exposed to the daylight color begins to form and most swiftly in those parts which are exposed to the sunlight, excepting that the perineal region of the infant is, at birth, quite highly pigmented. Eventually, however, about the same depth of pigmentation is achieved whether the child grows into a woman or a man. There seems to be no difference in the color of the mulatto children whether the dark parent be the father or the mother.

No correlation was found in these studies of the children of mulattoes between the color of the skin and the curliness of the hair; so that, indeed, white-skinned, kinky-haired children and black skinned, straight-haired children were not an uncommon occurrence.

Our studies, also, furnish no support for the view that hybrids are less fertile than pure races in man. Some of the most fecund families of Jamaica are those of mulattoes.

The Principles of Eugenics

Those who are seeking to retain the name "Eugenics" for that section of genetics which deals with man, are not likely to welcome the little book called "The Principles of Eugenics" by Blanche Eames, Assistant Principal of the Correspondence School of Gospel and Scientific Eugenics (Chicago), which has just been issued by Moffat, Yard and Company, New York (pp. 91, price 75 cents). The writer belongs to that school which sees in sex hygiene the principal factor of eugenics. "Heredity" is limited to one chapter of 12 pages, while the other chapters discuss Reproduction, Race Poisons, Instruction in Sex Truths, Tobacco and Drugs, Parental Nutrition and Environment (two chapters) and Continence. The author is a convinced, although not critical, disciple of Lamarck, and an equally convinced and uncritical believer in "prenatal culture," "maternal impressions" and similar phenomena which most genetists consider little better than superstitions. The book is sub-titled "A Practical Treatise," but the practical measures of eugenic import which the author proposes seem principally to consist of negative eugenics through asexualization and positive eugenics through proper mental attitude of expectant mothers. The JOURNAL OF HEREDITY can hardly accept this as a working program for the science of eugenics. The author has useful ideas on the subject of racial poisons and sex hygiene, and it is a pity that she could not present them except under the name of eugenics.

MISSING TEETH INHERITED

Lateral Incisors and Third Molars or "Wisdom Teeth" Most Frequently Absent—Cause to be Sought in Evolution of Man and Change of His Habits of Eating—Loss of Importance of Canine Teeth.

DR. SERGIO SERGI

Institute of Anthropology, Royal University of Rome, Italy.[1]

I HAVE made the acquaintance of an educated Piedmontese youth who shows the congenital absence of the upper lateral right incisor; he has informed me that his father, his two brothers and their two sisters, all older than he, present the same defect, as did an uncle, his father's only brother; and his paternal grandfather. In all of them, the absence of the tooth is accompanied by a noticeable reduction in size of the corresponding incisor on the left side.

Dental agenesia as a phenomenon of heredity has been noted by a number of observers in the past. Hereditary absence of the lateral incisors has been observed in two or three generations and the inheritance may be either direct or alternate. Magitot refers to a woman who showed a lack of the upper, lateral incisors, as did her daughter and nephew; and of a man who lacked the lateral upper right incisor, as did his daughter and his nephew; Leroy d'Etiolle describes the same sort of agenesia in a woman and her three sons.

Perrin has cited the case of a family in various members of which the two upper lateral incisors were lacking, and says the defect had existed in the family for many generations.

The phenomenon of congenital absence of teeth, like that of the augmentation of their number, is a form of meristic variation, according to Bateson's terminology, and usually appears as a form of discontinuous variation; it can not be considered in itself a fact of atavism, a phenomenon of reversion, but at the most a phenomenon of arrested development. I should note that Dependorf has recently also combated, to a certain extent, the explanation of atavism for supernumerary teeth, in which the idea of reversion is much more easily sustained than in agenesia, considering the phylogenetic evolution of the dental system from the lower to the higher vertebrates.

The congenital absence of incisors is in a way a teratological phenomenon, inasmuch as it appears unexpectedly in a given individual of the species, and no equivalent condition is found in the most closely related species; and it is particularly teratological in character if it is coupled with similar occurrences in the molar teeth. But at the same time, it is also a progressive phenomenon when it follows a law of evolution: so that the fact of lack of certain teeth can have different meanings according to the number or type of teeth wanting. It seems to me that the lack of the superior lateral incisors in man (or the presence of extra ones) indicates a new step in the so-called regressive evolution of the dental system, just as does the disappearance of the third molar (the *wisdom tooth.*)

EXPLANATION OF THE CONDITION.

Amadei in 1881 proposed the hypothesis that the same movement of evolution which tends to cause the disappearance of the last molar would make its action felt on the entire jaw, but particularly at its two centers of reduction: one corresponding to the location of the third molar and the other at the point where the lateral

[1]Translation and abridgment of "Mancanza congenita ed ereditaria di un incisivo," in Atti della Societá Romana di Antropologia, Vol. XV, p. 395, 1909.

incisor is located. This is the weak point because of orthognathism, and because of the tendency of the maxillary arch to become constantly more acute.

The phenomenon appears as a form of transition, in the subject which I examined, because one of the incisors is lacking and the other very slightly reduced in size, while the teeth between seem to attempt to compensate, by their notable increase in size, for the inadequate development of the laterals. To confirm this idea, it is sufficient to record an easily observed fact, and that is the frequency with which, in the skulls of civilized peoples, the upper medial incisors appear much enlarged and those beside them much reduced, a difference which is also observable in the skulls of prehistoric peoples. This morphological condition is an indication of the modified functional conditions to which man's teeth are subjected in comparison to those of the other vertebrates nearest to him in anatomy and relationship. The function of the incisors is essentially the seizing of food, and particularly the separation (*incidere*) of the part which is to be taken in the mouth, from that which remains in the hand; this function is preceded and then assisted to the highest degree by the canine teeth, which have to sieze and hold the prey during the time necessary for the *incisive* operation; the canines also have a special function as a weapon of offense and defense. In man this last function of the canines is abolished, while that of seizing is largely reduced in importance, particularly among civilized peoples; for these reasons the canines no longer project below the plane of the other teeth, and to that extent lose the characteristic pointed form which they have in other genera of vertebrates. When man eats, he first divides the food for chewing, principally by the use of his medial incisors and to a less extent with the lateral incisors; and particularly with those of the upper jaw, since it projects forward of the lower one. The food is then pushed into the mouth for mastication, and from then on the work of the lateral incisors and canines is very slight. The width to which man opens his mouth is small in comparison with its aperture, and in comparison with the habit of other vertebrates; this is because of his orthognathism or lack of "muzzle" and because of a diminution of his voracity, which leads him to introduce into his mouth only a small quantity of food at one time; these facts favor the action of the medial incisors and diminish the importance of the other incisors and the canines; the result is that the superior lateral incisors are now an organ subsidiary to the medials.

The Justification for Eugenics

Individuals appear to me as partial detachments from the infinite ocean of Being, and this world as the stage on which Evolution takes place, principally hitherto by means of Natural Selection, which achieves the good of the whole with scant regard to that of the individual.

Man is gifted with pity and other kindly feelings; he also has the power of preventing many kinds of suffering. I conceive it to fall well within his province to replace Natural Selection by other processes that are more merciful and not less effective.

This is precisely the aim of Eugenics. Its first object is to check the birth-rate of the Unfit, instead of allowing them to come into being, though doomed in large numbers to perish prematurely. The second object is the improvement of the race by furthering the productivity of the Fit by early marriages, and healthful rearing of their children. Natural Selection rests upon excessive production and wholesale destruction; Eugenics on bringing no more individuals into the world than can be properly cared for, and those only of the best stock.—Francis Galton: Conclusion to Memories of My Life (1908).

The Journal of Heredity

A monthly publication devoted to Plant Breeding, Animal Breeding and Eugenics

PLANT CHIMERAS - - - - - - The Editor

HEREDITY IN CHIMERAS - Dr. William S. Chapin

STUDIES IN HUMAN HEREDITY

The Committee on Research in Eugenics

SKIN COLOR OF MULATTOES - Charles B. Davenport

MISSING TEETH INHERITED - - Dr. Sergio Sergi

TITLE PAGE AND INDEX OF VOLUME V

ORGAN OF THE

AMERICAN GENETIC ASSOCIATION, Washington, D. C.

Printed for Circulation among Members Only

Vol. V, No. 12 **December, 1914**